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A LITERATURE REVIEW OF MILLIMETER AND SUBMILLIMETER RADIATION ABSORPTION AND SCATTERING IN THE ATMOSPHERE

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Water Vapor Absorption	Fog	Battlefield Smokes
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Oxygen Absorption	Snow	Index of Refraction for Dusts
Aerosols	Mm and Submm radiation	Atmospheric Index of Refraction
	Battlefield Dusts	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The presence on the electronic battlefield of smoke, dust, aerosols and exotic gases may seriously interfere with the effectiveness of battlefield radars in the millimeter and submillimeter wavelength range that have to operate in such an environment. This report describes a literature review that was performed on the absorption and scattering processes undergone by 100 μm to 1 cm wavelength radiation as it propagates through the atmosphere. Recommendations are given for further experimental and theoretical work that is needed to better define

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the absorption by atmospheric and battlefield generated gases and the scattering and absorption by atmospheric and battlefield generated aerosols and smokes. The Appendix contains a bibliography of the unclassified unlimited and limited distribution documents included in the literature review. The bibliography of the classified documents included in the literature review is given in Volume II of this report.

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I. INTRODUCTION

The presence of smoke, dust, aerosol and exotic gases on the battlefield may impair the effectiveness of battlefield radar in such an environment. The object of the work described in this report was to review the unclassified and classified literature on the absorption and scattering processes undergone by 100 μm to 1 cm wavelength radiation as it propagates through the atmosphere. The literature reviewed includes those papers that describe calculations and measurements of 100 μm to 1 cm wavelength radiation and absorption by normal atmospheric gases and by water vapor, rain, ozone, atmospheric aerosols, clouds, fogs, battlefield dust and smoke and the exotic gases produced by motorized equipment and weapons during battle.

The government report literature surveyed during this study is listed in Appendix A of this report. An NTIS literature survey was obtained for use in this study. The NTIS survey was entitled "Submillimeter Wavelength Radiation Absorption and Scattering by Atmospheric Gases, Water Vapor, Ozone, Aerosols, Clouds, Fog, Battlefield Dust and Smoke." A total of 51 reports listed in the NTIS survey was ordered for use in this study. A number of the reports listed in the NTIS survey were already available in the RRA document files. A total of 190 unclassified, 34 limited, and 14 classified government sponsored research reports were reviewed for this study. In addition, a number of books were reviewed and articles on millimeter radiation interactions in the atmosphere from the following journals were reviewed:

IEEE Transactions on Microwave Theory and Techniques, 1970-1977
IEEE Transactions on Antenna and Propagation, 1970-1977
Journal of the Optical Society of America, 1970-1977
Applied Optics
Infrared Physics, 1963-1977
Journal of Geophysical Research, 1963-1977

Journal of the Atmospheric Sciences, 1974-1976
Optics and Spectroscopy, (Russian Translation) 1970-1977
Radio Physics and Electronics (Russian Translation), 1969-1977
Nature and Nature/Physical Sciences, 1970-1977
Journal of the Faraday Society, 1970-1977 (and selected 1960's)
Optical Engineering, 1973-1978
Physical Review (selected articles), 1965-1975
Review of Modern Physics (selected articles), 1973-1978
Journal of Molecular Spectroscopy, 1967-1977

Section II gives a summary of the unclassified documents in the open literature on: 1) attenuation by atmospheric water vapor and oxygen, 2) atmospheric index of refraction, 3) attenuation and scattering by fog, rain and clouds, 4) attenuation and scattering by snow, 5) attenuation by Ozone, 6) attenuation and scattering by aerosols and dust and 7) attenuation and scattering by battlefield generated dusts and smokes. Section III gives a summary of the limited distribution, unclassified literature on attenuation and scattering by rain and hail, attenuation by water vapor and the refractive indices for sea spray. Section IV discusses the results of the review of the classified literature.

A bibliography of the unclassified literature is given in Appendix A. Section V describes the methods used to index the contents of the articles reviewed. Recommendations for further work that is needed to further the understanding of the interaction processes undergone by mm and sub mm radiation as it propagates in the atmosphere are given in Section VI.

II. SUMMARY OF LITERATURE SURVEYED

The following sections present data taken from the reviewed literature which describe the current state of knowledge on the interaction cross sections for millimeter and submillimeter radiation when it is propagated through the atmosphere.

2.1 Attenuation by Water Vapor and Oxygen

Corcoran[1] has presented a table (shown here as Table I) of the atmosphere "Windows" and bounding absorption peaks, from 3.2 cm to 156 μm for absorption due to water vapor and oxygen for a zenith path through a cloudless Maritime Polar atmosphere. The absorption is given for water vapor, oxygen, and combined gaseous attenuation for these chief atmospheric constituants.

Traub and Stier[2] has presented an atmospheric calculation for mid and far IR at 4 observing altitudes, 4.2 km (Mauna Kea), 14 km (aircraft), 28 km (balloon), and 41 km (balloon). Molecular abundances, effective pressures and temperatures used in the Curtis-Godson approximation as shown here in Table II (from Traub and Steier, Ref. 2). They used the AFCRL atmospheric absorption line parameter tape[3] to obtain the wavenumber, line strength, pressure broadening coefficient, and energy level of the lower state for over 109,000 known transitions of H_2O, O_3, O_2, CO_2, CO, N_2O, and CH_4 between .76 μm and 3.26 mm. Figure 1 presents the results of their calculations of atmospheric transmission from 100 μm to 1000 μm using the initial conditions shown in Table II. The "4 km" labeled curve is really for the 4.2 km altitude of Mauna Kea. The vertical ordinate, the transmission, unreadable in the curves of Fig. 1 is linear from 0 to 1. A Lorentz line profile was used for simplicity, though a Van Vleck-Weiskopf line profile would have been more accurate in the wings of each line.

Table I. Candidate "Windows" in the Submillimeter and Microwave Bands, Arising from Absorption Spectra of Water Vapor and Oxygen, with Attenuation in Decibels Calculated for a Zenith Path through a Cloudless Maritime Polar Atmosphere (from Ref. 1)

Window	Wavelength (approx.) of window at least gaseous absorption	Bounding Absorption Peaks		Attenuation (in decibels) along zenith path		
		Wavelength of peak absorption	Primary absorbing gas	By water vapor	By oxygen	Combined gaseous absorption
		No absorption of consequence at wavelengths greater than 3.2cm				
I	3.2cm			0.005	0.140	0.145
		1.3cm	Water vapor	0.408	0.200	0.608
II	9mm			0.074	0.340	0.414
		5mm	Oxygen	0.100	135.	135.1
III	3mm			0.253	1.00	1.253
		2.52mm	Oxygen	0.447	30.0	30.447
IV	2.3mm			0.506	0.40	0.906
		1.6mm	Water vapor	65.8	0.18	65.98
V	1.3mm			1.80	0.31	2.11
		920μ	Water vapor	90.9	0.68	91.58
VI	880μ			9.12	0.75	9.87
		780μ	Water vapor	621.	0.95	621.95
VII	720μ			20.9	1.10	22.00
		660μ	Water vapor	874.	1.30	875.30
VIII	650μ			64.8	1.40	66.20
		630μ	Water vapor	184.	1.50	185.50
IX	620μ			55.5	1.55	57.05
		530μ	Water vapor	37,100.	2.10	37,102.
X	490μ			189.	2.40	191.40
		475μ	Water vapor	690.	2.60	692.60
XI	450μ			72.0	2.90	74.90
		397μ	Water vapor	27,000.	3.80	27,003.8
XII	345μ			72.0	5.0	77.0
		325μ	Water vapor	1,450.	5.6	1,455.6
XIII	320μ			189.	5.8	194.8
		303μ	Water vapor	176,000.	6.5	176,006.5
XIV	290μ			360.	7.	367.
		256μ	Water vapor	187,000.	9.	187,009.
XV	237μ			540.	11.	551.
		215μ	Water vapor	176,000.	13.	176,013.
XVI	200μ			486.	15.	501.
		174μ	Water vapor	6,900.	(20.)	6,920.
XVII	164μ			1,230.	(22.)	1,252.
		156μ	Water vapor	6,900.	(25.)	6,925.

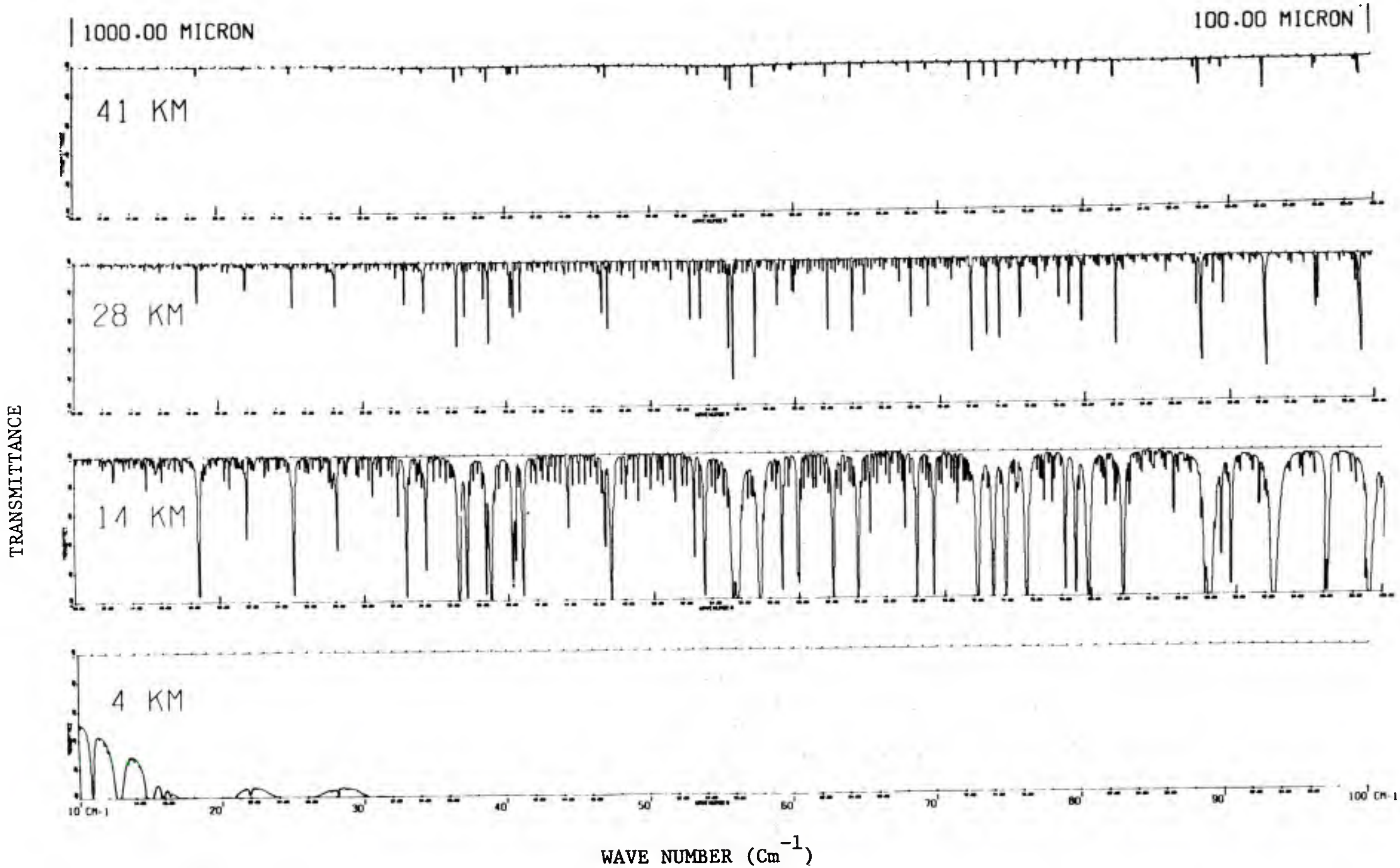


Fig. 1. Atmospheric Transmission at Four Altitudes with an Air Mass of 2.0 and a Rectangular Bandpass of 0.05 cm^{-1} width. (From Data in Ref. 2)

Table II. Molecular Abundances, Effective Pressures, and Temperatures Used in the Curtis-Godson Approximation[a,b]

	4.2 km (Mauna Kea)	14 km (Aircraft)	28 km (Balloon)	41 km (Balloon)
O_2	209460.0 ppmv	209460.0	209460.0	209460.0
CO_2	325.0 ppmv	325 0	325.0	325.0
CH_4	1.5 ppmv	1.1	0.8	0.4
N_2O	0.25 ppmv	0.20	0.20	0.20
CO	0.07 ppmv	0 06	0.06	0.06
H_2O	1200 μm	2.5 ppmv	2.5 ppmv	2.5 ppmv
O_3	7.28 E18 cm^{-2}	6.37 E18	1.85 E18	1.70 E17
p	600.0 mbar	141.6	16.2	2.52
p(eff)	300.0 mbar	70.8	8.10	1.26
$p(H_2O)$	506.0 mbar	70.8	8.10	1.26
$p(O_3)$	36.4 mbar	30.2	7.09	1.84
T(eff)	228.0 K	217.0	230 0	268.0
$T(H_2O)$	252.0 K	217.0	230.0	268.0
$T(O_3)$	219.0 K	221.0	233.0	260.0

[a] The H_2O abundances in the last three columns correspond to 2.25, 0.26, and 0.040 precipitable μm, respectively; the H_2O at 4.2 km is assumed to have a scale height of 1.85 km. The abundances listed are for unit air mass; an additional factor of 2 is included in the actual calculations corresponding to a zenith angle of 60°. The base pressure at each altitude is given by p, and the effective pressure for collisional line broadening is indicated by p(eff), $p(H_2O)$, and $p(O_3)$ for the first five species, H_2O, and O_3, respectively;the temperatures at the corresponding pressure levels are also listed.

[b] Data from Ref. 2.

Archie Straiton[4], in a tutorial article, presents the results of a calculation of the attenuation in the 10-400 GHz wave bands (3.33 cm - .75 mm) due to oxygen and water vapor in a vertical path from sea level for a standard atmosphere. His results are shown in Fig. 2. We see graphically the major absorption lines and windows of the microwave-mm wave region; below 100 GHz, the absorption spectrum is dominated by the "22" GHz water vapor line, and the "60" GHz molecular oxygen line. Attention has been placed on communication systems operating in the 35 GHZ and 93 GHz regions of transmission maximum for long range requirements, and in the 60 GHz region, for short range, secure communications. Some authors have utilized the water vapor lines (in emission) at 22 GHz and 183 GHz to measure the atmospheric water vapor content. In his calculation, Straiton used the Gross[5]/Zhevakin-Naumov[6] attenuations $\Gamma(\nu)$ at a frequency ν for a single line with center frequency ν_{ij}

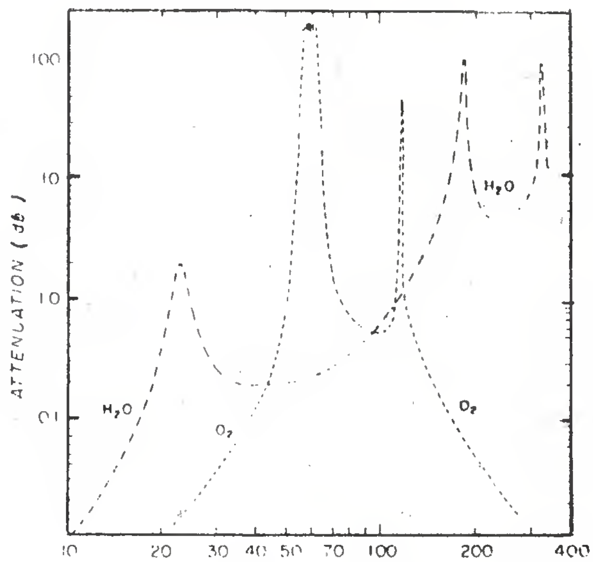
$$\Gamma(\nu) = \frac{S}{\pi} \frac{4\pi \nu^2 \alpha}{(\nu_{ij}^2 - \nu^2)^2 + 4\nu^2\alpha^2}$$

S = a measure of the strength of a line

α = approximately the change in frequency from ν_{ij} at which the attenuation has dropped to 1/2 (line breadth parameter = $\simeq\Delta\nu$)

Values of ν_{ij}, S, and α, which are given by Burch[7] for water vapor from 0.5 to 36 cm^{-1} are presented here as Table III. The water vapor line breadth parameter is given by (after Straiton, Ref. 4)

$$\Delta\nu = 2.62 \left(1 + 0.01 \frac{\rho T}{P}\right) \frac{(P/760)}{(T/3.18)^{0.625}} ,$$



Frequency (GHz)

Fig. 2. Oxygen and Water Vapor Attenuation Vertically from Sea Level (Data from Ref. 2)

Table III. Parameters for H_2O lines below 38.8 cm^{-1}.
(Data from Ref. 7)

ν_0 cm^{-1}	J' J''	τ' τ''	Isotope	Temperature 320°K	300°K	280°K	260°K	240°K	220°K
0.74	6	−5		$S = 1.35-2$	1.39−2	1.42−2	1.43−2	1.42−2	1.38−2
	5	−1		$\alpha° = 0.087$	0.090	0.094	0.099	0.104	0.110
2.27	4	−3		6.95−4	4.73−4	3.01−4	1.77−4	9.30−5	4.28−5
	3	1		0.091	0.095	0.099	0.10	0.11	0.12
2.69	1	1	D	6.47−4	7.53−4	8.85−4	1.05−3	1.26−3	1.54−3
	1	0		0.098	0.102	0.106	0.111	0.117	0.123
4.03	5	−4	D	6.75−4	7.42−4	8.16−4	8.98−4	9.89−4	1.09−3
	4	0		0.089	0.093	0.097	0.10	0.11	0.11
4.62	6	−5	D	5.15−4	5.52−4	5.91−4	6.30−4	6.67−4	7.01−4
	5	−1		0.086	0.090	0.094	0.098	0.10	0.11
4.80	4	0	D	9.86−4	1.09−3	1.20−3	1.32−3	1.45−3	1.60−3
	4	−1		0.088	0.091	0.095	0.099	0.10	0.11
6.11	3	−2		2.26	2.55	2.88	3.28	3.76	4.32
	2	2		0.092	0.096	0.100	0.105	0.111	0.117
6.79	3	−2	18	5.75−3	6.48−3	7.34−3	8.36−3	9.58−3	1.10−2
	2	2		0.092	0.096	0.10	0.11	0.11	0.12
8.06	2	0	D	2.79−3	3.22−3	3.75−3	4.40−3	5.21−3	6.26−3
	2	−1		0.096	0.10	0.10	0.11	0.12	0.12
8.50	5	−1	D	3.05−3	3.28−3	3.51−3	3.75−3	3.99−3	4.20−3
	4	1		0.085	0.089	0.093	0.098	0.10	0.11
8.90	2	2	D	3.11−3	3.54−3	4.06−3	4.68−3	5.44−3	6.38−3
	3	−2		0.092	0.096	0.10	0.11	0.11	0.12
10.74	10	−7		9.57−2	7.64−2	5.84−2	4.22−2	2.84−2	1.75−2
	9	−3		0.074	0.077	0.079	0.081	0.084	0.087
10.85	5	−4		2.77	2.95	3.14	3.33	3.51	3.65
	4	0		0.089	0.093	0.097	0.102	0.107	0.113
11.89	10	−7	18	2.44−4	1.95−4	1.49−4	1.08−4	7.28−5	4.48−5
	9	−3		0.075	0.077	0.079	0.082	0.085	0.088
12.68	4	−3		2.47+1	2.72+1	2.99+1	3.30+1	3.64+1	4.02+1
	3	1		0.091	0.095	0.099	0.104	0.109	0.115
13.05	4	−3	18	5.38−2	5.93−2	6.54−2	7.21−2	7.96−2	8.78−2
	3	1		0.091	0.095	0.099	0.10	0.11	0.12
13.10	10	−4		1.14−2	8.43−3	5.92−3	3.89−3	2.34−3	1.26−3
	11	−8		0.069	0.070	0.072	0.074	0.076	0.078
14.58	7	2		1.77−1	1.52−1	1.25−1	9.96−2	7.48−2	5.23−2
	6	6		0.049	0.050	0.051	0.052	0.053	0.055
14.65	6	1		2.43	2.28	2.10	1.88	1.62	1.34
	5	5		0.064	0.065	0.067	0.068	0.070	0.073
14.78	7	3		5.45−1	4.67−1	3.87−1	3.07−1	2.31−1	1.61−1
	6	5		0.049	0.050	0.051	0.053	0.054	0.056
14.92	4	−1		2.62+1	2.82+1	3.03+1	3.25+1	3.46+1	3.66+1
	3	3		0.080	0.082	0.085	0.089	0.092	0.097
15.68	6	2		9.29−1	8.72−1	8.01−1	7.16−1	6.18−1	5.10−1
	5	4		0.061	0.063	0.065	0.066	0.069	0.071
15.87	5	0		3.51	3.55	3.56	3.52	3.42	3.24
	4	4		0.067	0.069	0.071	0.073	0.075	0.078
16.29	6	−2		7.05−1	6.93−1	6.72−1	6.39−1	5.93−1	5.32−1
	7	−6		0.083	0.086	0.090	0.093	0.098	0.103
16.30	4	−1	18	6.49−2	6.99−2	7.51−2	8.06−2	8.60−2	9.12−2
	3	3		0.079	0.082	0.085	0.088	0.089	0.096
16.79	8	3		1.27−1	9.82−2	7.21−2	4.98−2	3.18−2	1.84−2
	7	7		0.042	0.042	0.043	0.044	0.046	0.047
16.82	8	4		4.26−2	3.28−2	2.41−2	1.67−2	1.06−2	6.15−3
	7	6		0.042	0.042	0.043	0.045	0.046	0.047
16.96	1	1	D	1.85−1	2.16−1	2.54−1	3.03−1	3.66−1	4.48−1
	1	−1		0.107	0.111	0.116	0.122	0.128	0.135
18.26	1	1	18	2.95	3.43	4.03	4.78	5.75	7.01
	1	−1		0.107	0.111	0.116	0.122	0.128	0.135
18.58	1	1		1.49+3	1.73+3	2.04+3	2.42+3	2.91+3	3.54+3
	1	−1		0.107	0.111	0.116	0.122	0.128	0.136
19.99	2	0	D	3.38−1	3.90−1	4.55−1	5.35−1	6.36−1	7.66−1
	2	−2		0.100	0.104	0.109	0.115	0.121	0.129
20.71	5	1		1.82+1	1.84+1	1.84+1	1.82+1	1.76+1	1.67+1
	4	3		0.073	0.076	0.079	0.083	0.087	0.092
21.96	1	1		1.59	1.15	7.78−1	4.92−1	2.83−1	1.45−1
	1	−1		0.107	0.111	0.116	0.122	0.128	0.135
24.84	2	0	18	2.02	2.31	2.67	3.11	3.66	4.34
	2	−2		0.100	0.104	0.109	0.115	0.121	0.129
25.09	2	0		1.00+3	1.15+3	1.33+3	1.55+3	1.82+3	2.16+3
	2	−2		0.100	0.104	0.109	0.115	0.122	0.129

The table is to be read as indicated by the following example for the 0.74 cm^{-1} line. $J' = 6$, $J'' = 5$, $\tau' = -5$, $\tau'' = -1$, $S = 1.35 \times 10^{-2}$ g^{-1} cm^2, $\alpha° = 0.087$ cm^{-1}. The isotope is H_2O^{16} unless indicated otherwise; D corresponds to HDO, 18 to H_2O^{18}.

Table III. (Continued)

ν_0 cm^{-1}	J' J''	τ' τ''	Isotope	Temperature 320°K	300°K	280°K	260°K	240°K	220°K
28.07	10	−1		9.15−2	6.45−2	4.27−2	2.62−2	1.46−2	7.14−3
	11	−7		0.052	0.053	0.053	0.054	0.055	0.056
28.31	2	−1	D	6.84−2	7.93−2	9.28−2	1.10−1	1.31−1	1.59−1
	1	0		0.095	0.099	0.10	0.11	0.12	0.12
28.68	2	0		1.03	7.29−1	4.87−1	3.02−1	1.70−1	8.44−2
	2	−2		0.100	0.104	0.109	0.115	0.121	0.129
29.77	1	0	D	3.99−1	4.67−1	5.52−1	6.60−1	8.00−1	9.85−1
	0	0		0.096	0.100	0.105	0.110	0.117	0.124
30.00	2	−2		4.34−1	3.11−1	2.10−1	1.32−1	7.50−2	3.79−2
	1	0		0.099	0.103	0.108	0.113	0.119	0.126
30.13	3	−1		3.13−1	2.17−1	1.41−1	8.49−2	4.61−2	2.20−2
	2	1		0.092	0.095	0.098	0.10	0.11	0.11
30.23	9	−6		1.03	8.79−1	7.25−1	5.72−1	4.28−1	2.97−1
	8	−2		0.077	0.080	0.083	0.086	0.089	0.094
30.56	4	0		4.34+1	4.66+1	4.99+1	5.33+1	5.67+1	5.97+1
	3	2		0.083	0.086	0.091	0.095	0.100	0.107
32.37	5	−2		5.07+1	5.28+1	5.47+1	5.62+1	5.70+1	5.70+1
	4	2		0.080	0.083	0.086	0.090	0.094	0.098
32.91	2	−2		7.17+2	8.29+2	9.67+2	1.14+3	1.36+3	1.64+3
	1	0		0.099	0.103	0.108	0.113	0.120	0.127
33.21	3	−3	D	5.30−1	6.20−1	7.17−1	8.38−1	9.88−1	1.18
	2	−1		0.095	0.099	0.10	0.11	0.11	0.12
33.47	5	−2	18	6.88−2	7.18−2	7.44−2	7.65−2	7.77−2	7.78−2
	4	2		0.080	0.083	0.086	0.090	0.094	0.099
33.68	2	0	D	9.45−2	1.09−1	1.28−1	1.51−1	1.80−1	2.17−1
	1	1		0.100	0.104	0.108	0.113	0.119	0.125
36.59	3	−1		4.87+3	5.46+3	6.15+3	6.96+3	7.91+3	9.02+3
	3	−3		0.095	0.099	0.104	0.110	0.116	0.124
36.74	1	0	18	2.83	3.31	3.91	4.67	5.65	6.95
	0	0		0.096	0.100	0.105	0.110	0.117	0.124
37.14	1	0		1.41+3	1.65+3	1.95+3	2.33+3	2.82+3	3.47+3
	0	0		0.096	0.100	0.105	0.111	0.117	0.124
37.90	3	1	18	1.05+1	1.17+1	1.30+1	1.45+1	1.62+1	1.81+1
	3	−1		0.091	0.095	0.100	0.10	0.11	0.12
38.24	7	−3		3.74	3.49	3.19	2.84	2.44	2.00
	8	−7		0.078	0.080	0.083	0.086	0.089	0.093
38.45	3	−1		7.41+2	8.32+2	9.37+2	1.06+3	1.21+3	1.38+3
	2	1		0.091	0.095	0.099	0.104	0.109	0.115
38.62	6	−1		8.18+1	7.96+1	7.62+1	7.15+1	6.53+1	5.75+1
	5	3		0.070	0.071	0.073	0.076	0.078	0.081
38.79	3	1		5.37+3	5.96+3	6.63+3	7.39+3	8.25+3	9.23+3
	3	−1		0.091	0.095	0.099	0.105	0.111	0.117

where ρ = water vapor density in gm/cm^3

T = absolute temperature, °K

P = pressure in mm mercury.

For water vapor, in the Gross equation for the attenuation, the strength function S is

$$S \sim \rho T^{-5/2} \exp(-a/T),$$

where a varies from line to line.

The line breadth depends on the collisions of the polar molecules with like molecules and other molecules in the atmosphere. For oxygen, Meeks and Lilley[8] give the line breadth $\Delta\nu(P_1 T)$ by the equation

$$\Delta\nu(P_1 T) = A\,P\left[0.21 + 0.78B\right]\left[\frac{T_o}{T}\right]^{0.85}$$

where A specifies the line broadening at unit pressure (= 1.95MHZ(mmHgΓ))

and B specifies the relative effectiveness of the $N_2 - O_2$ collisions as compared to the $O_2 - O_2$ collisions (= .25 for pressures less than 267mmHg).

In a report by Richard Longbothum[9], the water vapor resonant scattering cross sections σ (for high altitudes, 30 -80 km) at 22 GHz (22.235 GHz, or 1.35 cm) and at 183 GHz (183.31 GHz or 1.64mm) are given by

$$\sigma(\nu,T,N,\nu_o) = \frac{K_a(\nu.T,N,\nu_o)}{N(h)},$$

where

$N(h)$ = number of water vapor molecules/cm^3 for a path length h.

At 22.235 GHz, the absorption coefficient K_a, for a pressure broadened line[10], is given by

$$K_a = 1.05 \times 10^{-28} \frac{N\nu^2}{T^{5/2}} \exp(-644/T) \left[\frac{\Delta\nu}{(\nu-\nu_0)^2+\Delta\nu^2} + \frac{\Delta\nu}{(\nu+\nu_0)^2+\Delta\nu^2}\right]$$

$$+ 1.52 \times 10^{-52} \frac{N\nu^2\Delta\nu}{T^{3/2}} \quad cm^{-1}$$

where

N = Number density of water vapor molecules in a cm^3

ν = frequency in Hertz

T - Kinetic temperature in °K.

At 183.31 GHz, the absorption coefficient for a pressure broadened line is (after Croom, Ref. 11)

$$K_a = 6.46 \times 10^{-29} \frac{N\nu^2}{T^{5/2}} \exp(-200/T) \left[\frac{\Delta\nu}{(\nu-\nu_0)^2+\Delta\nu^2} + \frac{\Delta\nu}{(\nu+\nu_0)^2+\Delta\nu^2}\right]$$

$$+ 1.8 \times 10^{-52} \frac{N\nu^2\Delta\nu}{T^{3/2}} \ cm^{-1}.$$

When both doppler and pressure broadening are applicable (altitude above 70 km) the 1/2 width $\Delta\nu$ is given by

$$\Delta\nu \simeq (\Delta\nu_p{}^2 + \Delta\nu_D{}^2)^{1/2}.$$

The pressure broadening $\Delta\nu_p$ is given by (Croom, Ref. 11) as

$$\Delta\nu_p = 2.62 \times 10^9 \frac{\left(\frac{P}{1013.25}\right)}{(T/318)^{0.625}} \cdot (1 + 0.0046\rho) \ Hz,$$

where

P = total atmospheric pressure in mb

ρ = density of water vapor in gm m^{-3}

T = kinetic temperature in °K.

The doppler broadening $\Delta\nu_D$ is given by (Croom, Ref. 11) as

$$\Delta\nu_D = 8.45 \times 10^{-7} \nu_o \sqrt{T} \ Hz.$$

A plot of the absorption cross sections for the two main lines, at 22 and 183 GHz, is shown in Fig. 3. Data for this plot is tabulated in Table IV. These data were abstracted from Longbothum, Ref. 9. Persual of this table (which includes line widths) shows the broadening of line widths of the absorption cross sections as the altitude decreases from 120 km to 30 km.

One variable that is often elusive in a set of atmospheric transmission measurements is that of the water vapor pressure and atmospheric water content. These two parameters are presented next as Fig. 4, atmospheric water vapor content and Fig. 5, water vapor pressure as a function of temperature and relative humidity. Both of these curves are from A. R. Downs[12].

Before leaving the discussion of basic atmospheric attenuation of mm and sub mm wavelengths, mention should be made of two papers on the physical properties of the oxygen molecule. Welch and Mizushima[13] have given a table of observed and calculated frequencies of the O_2 molecule, from 53.066 GHz to 3865.81 GHz (given here as Table V). A result of a nonlinear least squares fit to 25 microwave and 3 sub mm and IR wavelengths is a set of molecular parameters for O_2, given here as Table VI.

Ott and Thomson[14] discussed the index of refraction of air (oxygen) in the 55-65 GHz region in their article "Characteristics of a Radio Link in the 55-65 GHz range." They give the path averaged refractive index $n(\nu)$ as a sum of frequency dependent and independent parts,

$$n(\nu) = 1 + \frac{77.63}{T}\left(P + \frac{4810e}{T}\right) \cdot 10^{-6}$$

$$+ \frac{(S/\gamma)\cdot 10^{-4}}{(-i + Z)} \cdot \left(\frac{300}{T}\right)^2 \left(\frac{P}{1013.25}\right)$$

with $Z = (\nu_0 - \nu)/\gamma$

T = absolute temperature °K

P and e are in millibars (1 mb = 0.75006376 Torr).

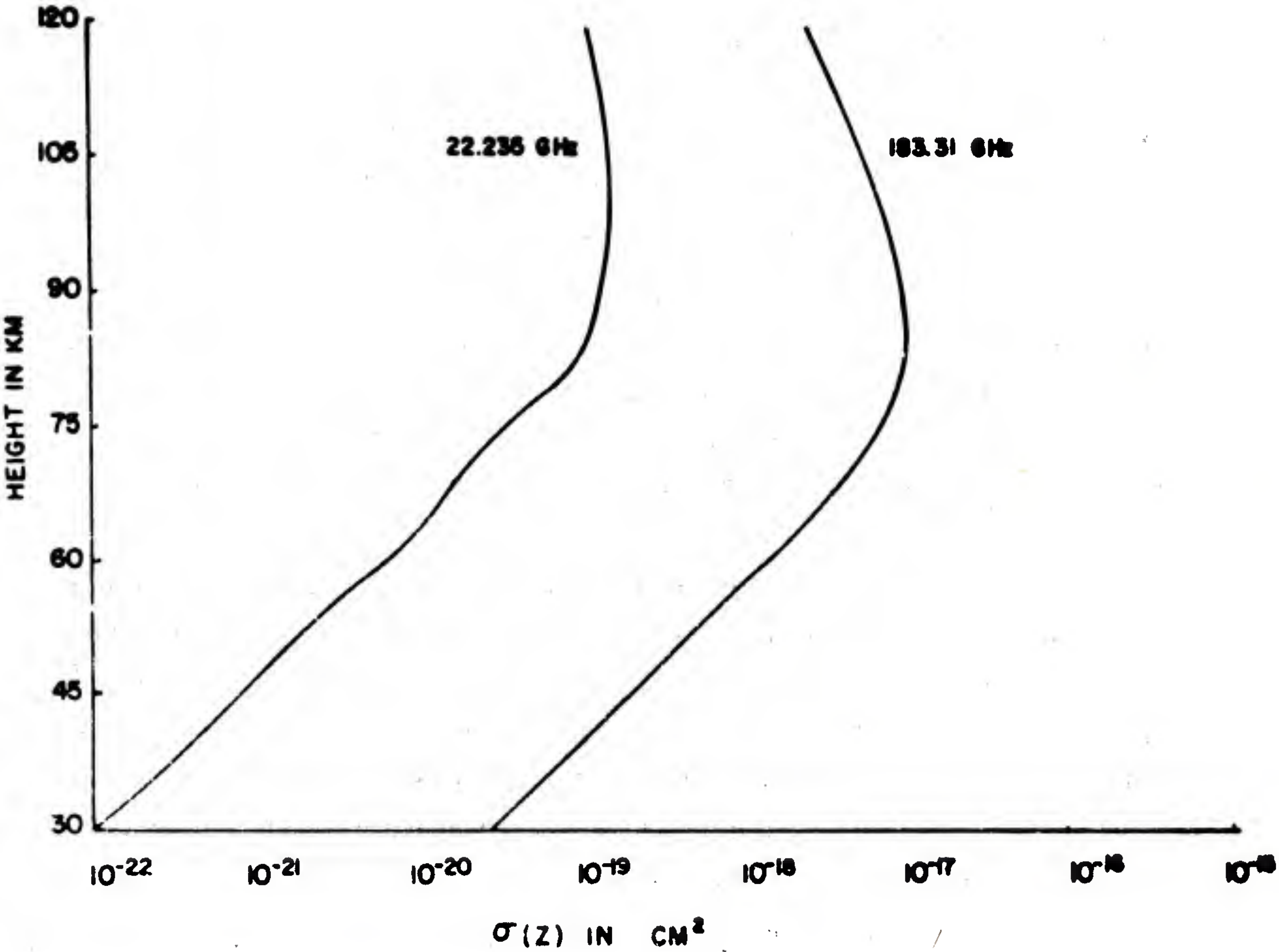


Fig. 3. Absorption Cross Sections for Water Vapor at 22.235 and 183.31 GHz vs. Height (Data from Ref. 9)

Table IV. Absorption Cross Sections for Water Vapor

(Data from Ref. 9)

h	$\Delta\nu_{22}$ *	$\Delta\nu_{183}$ *	$\sigma_{22}(h)$	$\sigma_{183}(h)$
30 km	4.0×10^{7} Hz	4.0×10^{7} Hz	1.0×10^{-22} cm^2	2.6×10^{-20} cm^2
40 km	9.7×10^{6} Hz	9.7×10^{6} Hz	4.0×10^{-22} cm^2	9.5×10^{-20} cm^2
50 km	2.7×10^{6} Hz	2.7×10^{6} Hz	1.5×10^{-21} cm^2	3.1×10^{-19} cm^2
60 km	6.6×10^{5} Hz	7.1×10^{5} Hz	6.1×10^{-21} cm^2	1.3×10^{-18} cm^2
70 km	2.3×10^{5} Hz	3.3×10^{5} Hz	1.7×10^{-20} cm^2	3.9×10^{-18} cm^2
80 km	5.0×10^{4} Hz	2.1×10^{5} Hz	6.6×10^{-20} cm^2	8.3×10^{-18} cm^2
90 km	2.6×10^{4} Hz	[illegible].1 $\times 10^{5}$ Hz	1.3×10^{-19} cm^2	7.8×10^{-18} cm^2
100 km	2.8×10^{4} Hz	2.2×10^{5} Hz	1.4×10^{-19} cm^2	5.8×10^{-18} cm^2
110 km	3.0×10^{4} Hz	2.5×10^{5} Hz	1.3×10^{-19} cm^2	3.7×10^{-18} cm^2
120 km	3.5×10^{4} Hz	2.9×10^{5} Hz	1.0×10^{-19} cm^2	1.9×10^{-18} cm^2

* (See **Appendix A** of Ref. 9)

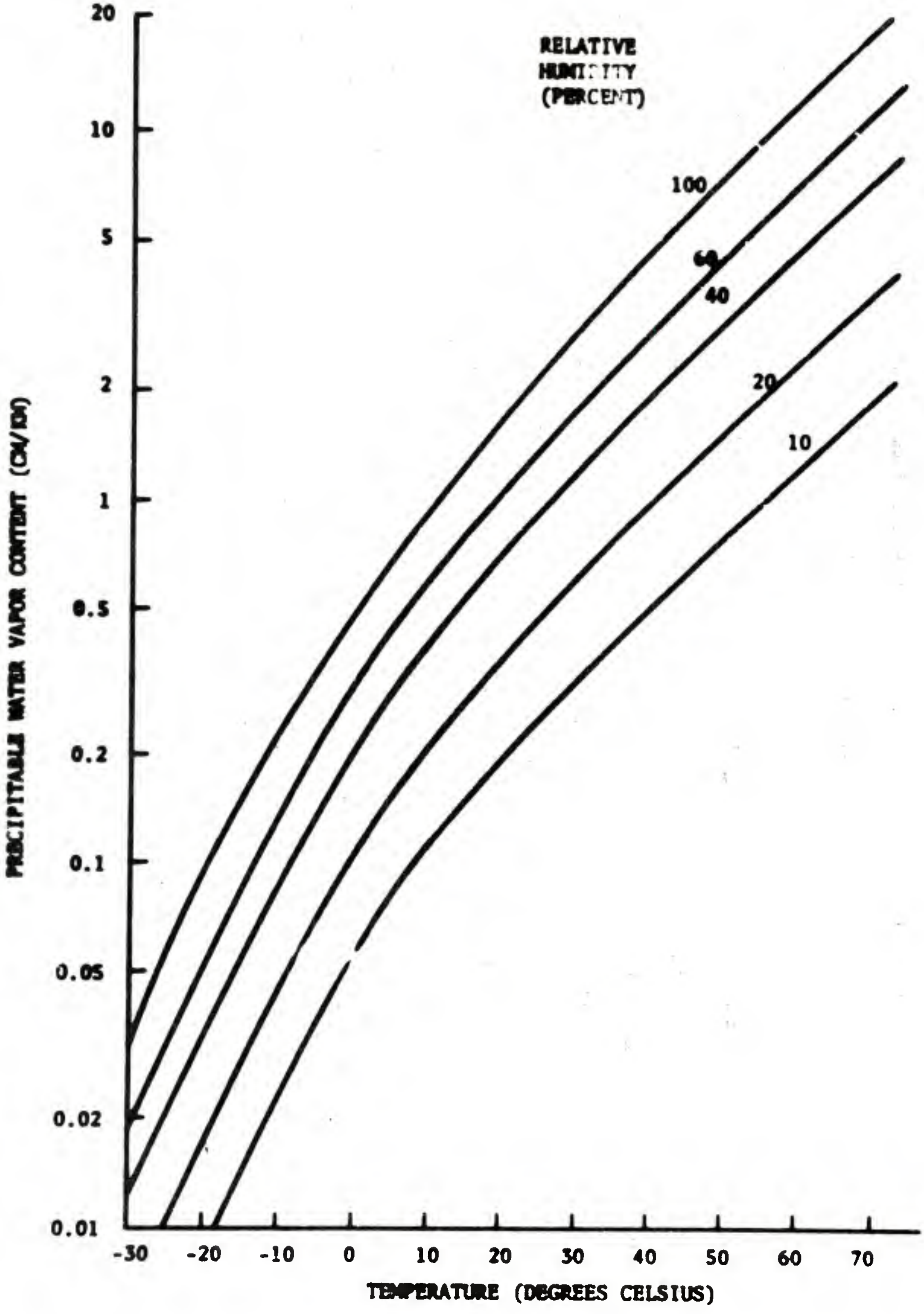


Fig. 4. Atmospheric Water Vapor Content (Data from Ref. 12)

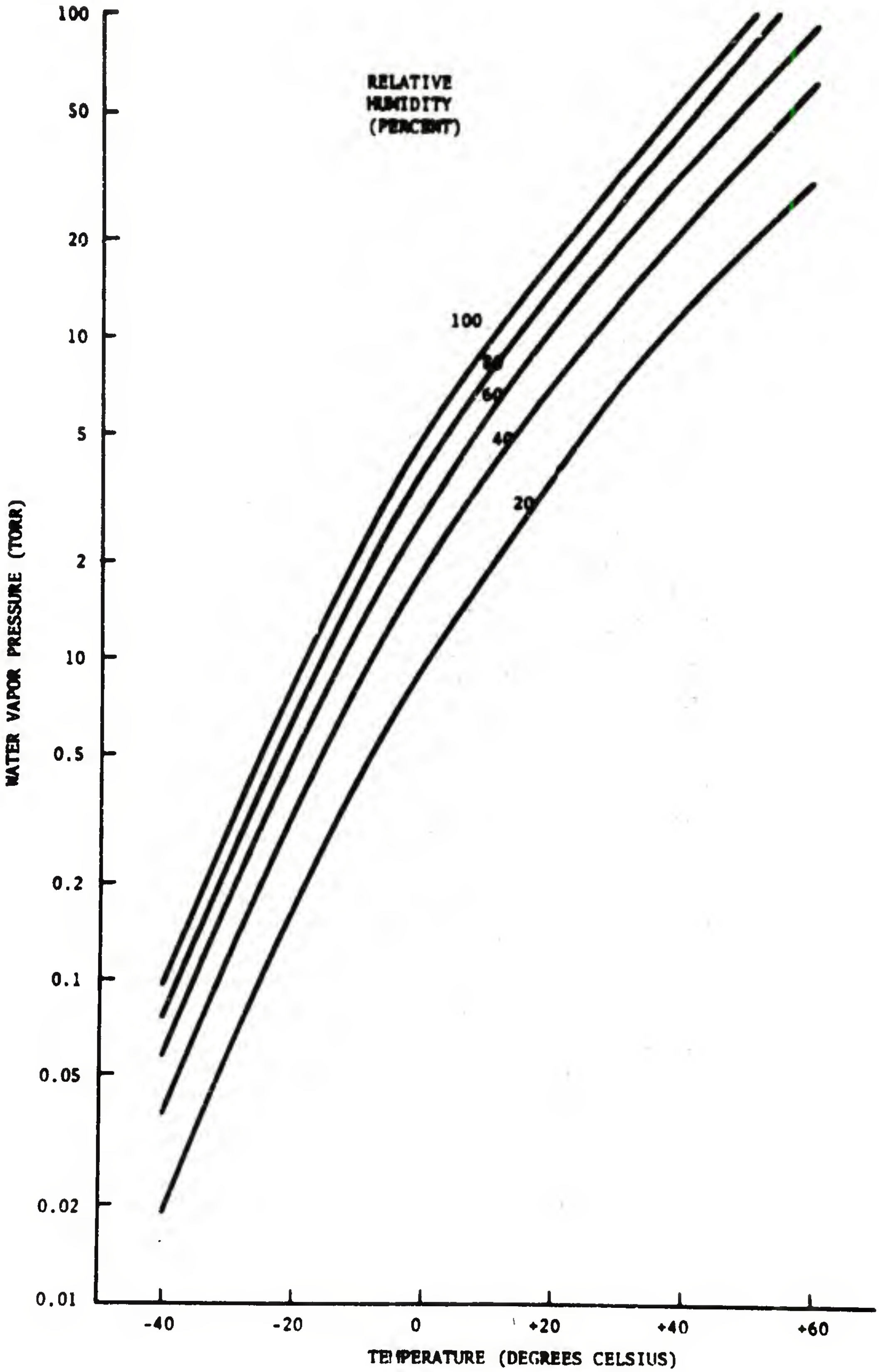


Fig. 5. Water Vapor Pressure as a Function of Temperature and Relative Humidity (Data from Ref. 12)

Table V. Observed and Calculated Frequencies of Oxygen Lines (GHz).

Transition $n, J[\rightarrow]n', J'$		Observed frequency[a]	Calculated frequency
1,2	1,1	56.264 778(M) 56.264 766(W)	56.264 758
3,4	3,3	58.446 600(M) 58.446 580(Z)	58.446 580
5,6	5,5	59.590 978(Z)	59.590 979
7,8	7,7	60.434 776(Z)	60.434 778
9,10	9,9	61.150 570(Z)	61.150 567
11,12	11,11	61.800 169(W) 61.800 155(Z)	61.800 167
13,14	13,13	62.411 223(Z)	62.411 234
15,16	15,15	62.996 6(H)[b]	62.997 999
17,18	17,17	63.568 520(Z)	63.568 542
19,20	19,19	64.127 777(W)	64.127 790
21,22	21,21	64.678 2(H)[b]	64.678 920
23,24	23,23	65.224 12(Z)	65.224 076
25,26	25,25	65.764 744(W)	65.764 760
1,0	1,1	118.750 343(M)	118.750 330
3,2	3,3	62.486 255(Z) 62.486 255(M)	62.486 267
5,4	55,5	60.306 044(Z)	60.306 065
7,6	7,7	59.164 215(Z)	59.164 211
9,8	9,9	58.323 885(Z)	58.323 883
11,10	11,11	57.611 4(H)[b]	57.612 492
13,12	13,13	56.968 140(W)	56.968 214
15,14	15,15	56.363 393(W)	56.363 397
17,16	17,17	55.783 819(W)	55.783 805
19,18	19,19	55.221 372(W)	55.221 362
21,20	21,21	54.671 145(W)	54.671 141
23,22	23,23	54.129 4(H)[b]	54.129 962
25,24	25,25	53.599 4(H)[b]	53.595 682
27,26	27,27	53.066 8(Wa)	53.066 802
1, 1	3, 3	430.985 277(M)	430.985 276
13,13	15,15	2 496.283 (E)	2 496.283
21,21	23,23	3 865.81(E)	3 865.810

[a](E) See Ref. 12, (H) see Ref. 7, (M) see Ref. 11, (W) see Ref. 6, (Wa) see Ref. 10, (Z) see Ref. 5.

[b]Line not included in fit.

Note: The references indicated above are references in Ref. 13 of this report.

Table VI. Molecular Parameters of Oxygen Molecule

(GHz)

(Data from Ref. 13)

Parameter	Wilheit and Barrett	Butcher, et al.	Present Work
B_o	43.100589	43.10059 (27)	43.100518 (3)[a]
B_1	-1.4×10^{-4}	-1.454 (4) $\times 10^{-4}$	-1.449629 (9) $\times 10^{-4}$
B_2			-1.57 (11) $\times 10^{-10}$
λ_o	59.501346		59.501342 (7)
λ_1	5.845×10^{-5}		5.847 (3) $\times 10^{-5}$
μ_o	-0.2525917		-0.2525865 (10)
μ_1	-2.455×10^{-7}		-0.2464 (20) $\times 10^{-7}$

Note: The statistical uncertainties quoted are approximately two standard deviation limits and do not include explicitly experimental uncertainties of the frequencies measurements. The standard deviations were estimated from the last iteration of the nonlinear fitting procedure based upon Taylor-series expansion about the estimated values.

These authors choose to use a "Lorentzian" line shape:

$S = 5220$ Hz

$\gamma = 3.92$ GHz = line width

ν_0 = center frequency in GHz

Different authors seemed to have "favorite" collision broadened reasonant line width functions (equivalent reasonant cross sections); from data by Burch (7), the experimental values favor (for $\nu < 15.5$ cm^{-1}, $\lambda > .645$ mm) the Van Vleck-Weiskopf function. Above that frequency ($\lambda < .645$mm) Burch feels that the Gross/Zhevakin-Naumov form fits the data on water vapor best.

The general data coverage on atmospheric transmission is heavier on the microwave - mm wave end than it is on the 100 μm end. A rough estimate is that there are 3 - 5 times the experimental and theoretical article coverage at the 30-300 GHz end (1 cm - 1 mm) than there is from 1 mm to 100 μm.

As a final note on general atmosphere transmission, we would like to mention the following five papers which have attenuation calculations and measurements, line width functions, etc:

a) "Atmospheric Absorption of Radio Waves Between 150 and 350 GHz" by F. T. Ulaby and Archie Straiton[16].

b) "Calculations of Antenna Temperature, Horizontal Path Attenuation and Zenith Attenuation due to Water Vapor in the Frequency Band 150 - 700 GHz" by R. W. McMillan, J. J. Gallagher, and A. M. Cook[17]

c) "Water Vapor Absorption Spectra of the Upper Atmosphere" (45-185 cm), by G. C. Auguson, A. J. Mord et al.[18]

d) "Method of Calculating the Atmospheric Water Vapor Absorption of MM and Sub MM Waves" by A. Yu. Zrazkevskiy[19]

e) "Temperature Dependence of the Absorption of Radio Waves by Atmospheric Water Vapor at the 10 cm - 0.27 mm Wavelengths," by K. A. Aganbekyan, A. Yu. Zrazkevskiy and V. G. Malinkin.[20]

Two curves from McMillan et al[17] serve to summarize much of the atmospheric attenuation data in the mm - sub mm range. Fig. 6 presents horizontal-path attenuation vs. frequency at sea level, and Fig. 7 presents the total zenith attenuation from sea level.

2.2 Atmospheric Index of Refraction

The atmospheric index of refraction is an important parameter which has received much less attention in the literature than atmospheric propagation. An illustration of the problem is from Davis and Cogdell[15] who measured the "differential refractive index" with their 16 foot antenna on Mt. Locke. This is a measure of the difference in pointing direction between optical and radio frequency waves and for some high resolution antennae, this difference (antenna point angle error) can be on the order of the beam width of the antennae. Davis and Cogdell's analysis of their data suggests that the refractive index is fairly well known up to 100 GHz and is given by

$$N = (77.6P/T)\left[1 + (4810/T)\,(e/p)\right].$$

where T = temperature ^{o}K

P = pressure in mbar

e = water vapor partial pressure in mbar.

Above 100 GHz and below the 140 GHz atmospheric window there is a downward break in the index of refraction as a function of frequency.

In retrospect, one would expect a set of "sag effects" in the antenna pointing error each time the frequency crosses a main atmosphere resonance line. The main absorption lines, below 200 GHz, are at 22 and 183 GHz (water vapor) and at 60 and 118 GHz (O_2). Davis and Cogdell saw their "sag effect" in the antenna point angle error on either side (97 and 140 GHz) of the 118 GHz O_2 resonance line. It is suspected that

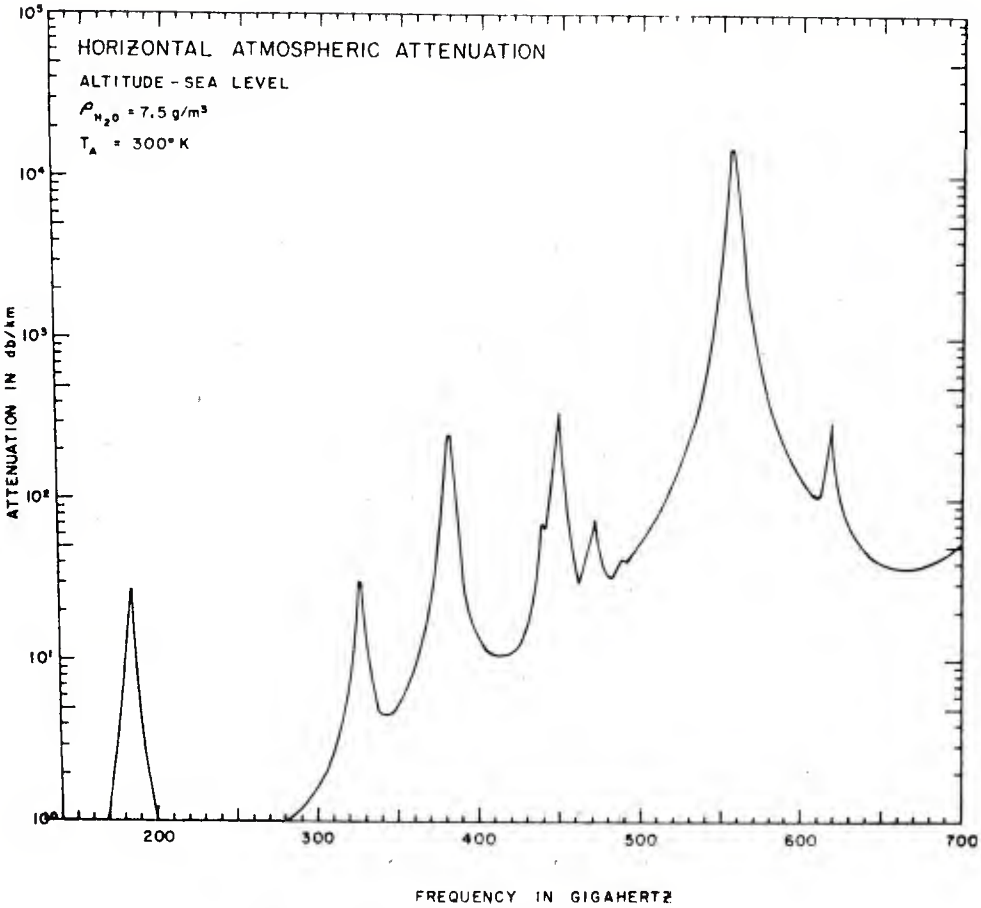


Fig. 6. Horizontal-path Attenuation Versus Frequency at Sea Level (Data from Ref. 17)

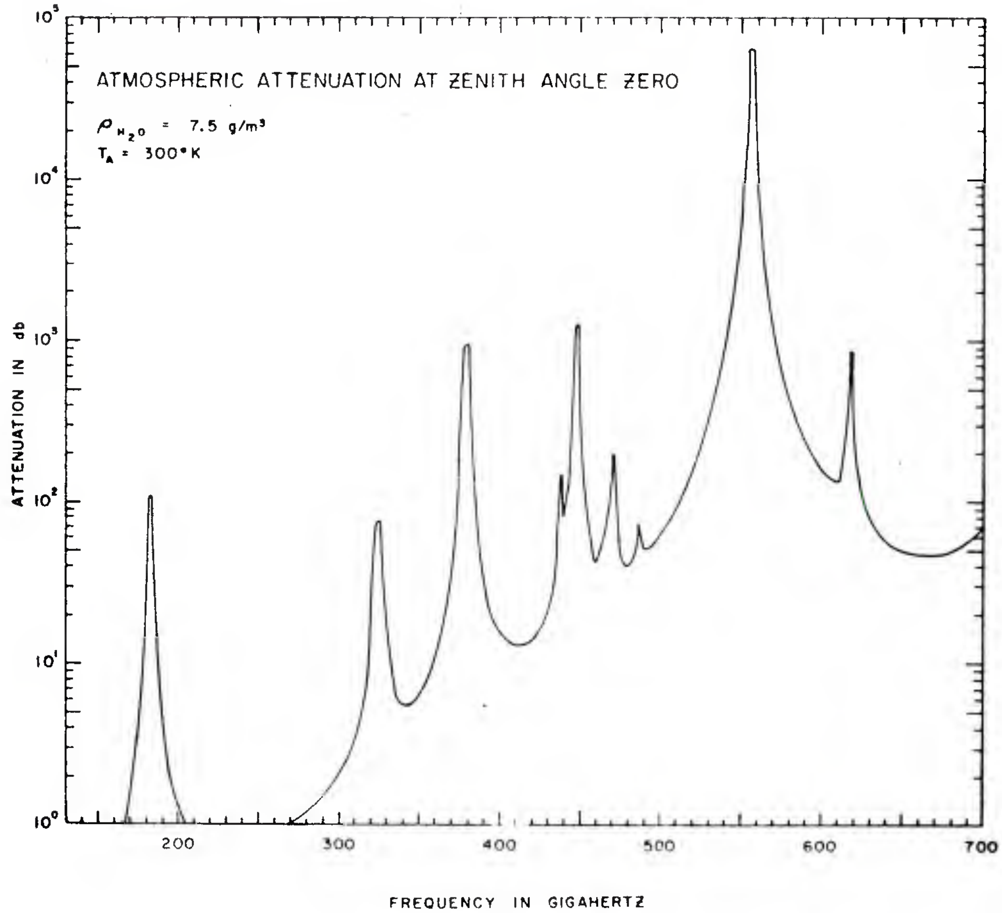


Fig. 7. Total Zenith Attenuation from Sea Level (Data from Ref. 17)

this sort of thing will happen on each side of major atmospheric reasonances, at the frequencies noted just previously, and at higher frequencies, as per the tables of resonances by Corcoran (Table 1) and by Burch (Table III). Also, as the atmospheric attenuation is a function of the relative humidity, so is the index of refraction; one might question if the "sag effect" is more pronounced about either side of the water vapor resonance/absorption lines than about the 60 and 110 GHz oxygen line.

2.3 Attenuation and Scattering by Fog, Rain and Clouds

If one knew the size distribution of the water droplets contained in fog, rain or clouds and the complex index of refraction for water as a function of wavelength and temperature, then it is possible to determine the scattering, absorption and extinction cross sections and the phase function with the application of Mie theory. The data available on the complex index of refraction is not very complete and there is not very good agreement in the various published values as a function of wavelength and temperature. For 20°C water, Deirmendjian[21,22] has compiled a set of measured data from 12 μm to 1000 μm. For wavelengths between 2 mm and 33 mm Deirmendjian used the Debye equation to compute the complex index of refraction for water.

Table VII presents Deirmendjian's collection of complex index of refraction data for water. Dorothy Stewart[23] has tabulated a set of indexes of refraction at 4 wavelengths, .55 μm, 10.6 μm, 870 μm, and 1250 μm. Table VIII lists the data she used in her very comprehensive article on infrared and submillimeter extinction by fog. She mentions in her article about recent sources of complex index of refraction data on water. Table IX, from the 1971 Chemical Rubber Company Handbook of Chemistry and Physics,[24] is a listing of data from two different groups on how the static dielectric constant of water varies with temperature. The static dielectric constant is not a constant, as usually assumed, but varies with temperature. Hale and Querry[25] did a very extensive survey of the optical constants of water with 59 reference listings; they computed the real part of the index of refraction doing a Cauchy principle value integration of smooth curve fits of all available data on the imaginary parts of the index of refraction, k(λ), of water, from 200 nm to 1 meter wavelength. They produced a table for the complex index of refraction of water from 20 nm to 200 μm (just the 100 μm - 200 μm section is reproduced here as Table X.) R. K. Crane[26] in his article "Microwave Scattering Parameters for New England Rain" presented two sets of calculations of the microwave index of refraction: one set was based on Debye's formula of the index of refraction of water using Kerr coefficients and the other set is attributed by Crane to Grant *et al*. The results of these calculations

Table VII. Complex Indices of Refraction vs Wavelength for Water (From Refs. 21, 22)

λ	Index of Refraction	λ	Index of Refraction
12.μm	1.111 - 0.199i	500.μm	2.22 - 0.740i
17.μm	1.376 - 0.429i	700.μm	2.32 - 0.890i
28.μm	1.549 - 0.338i	1000.μm	2.50 - 1.09i
40.μm	1.519 - 0.385i		
60.μm	1.703 - 0.587i	2.mm	2.5604 - 0.8947i
100.μm	2.06 - 0.551i	5.mm	3.1918 - 1.7657i
140.μm	2.07 - 0.470i	10.mm	4.2214 - 2.5259i
200.μm	2.08 - 0.509i	20.mm	5.8368 - 3.0046i
337.μm	2.20 - 0.600i	33.mm	7.1755 - 2.8642i

Table VIII. Indices of Refraction for Water (From Ref. 23)

Source	Wavelength (μm)	Index of Refraction
Hale and Querry (1973)	0.55	$1.333 - 1.96\ (10^{-9})\ i$
Hale and Querry (1973)	10.5	1.185 - 0.0662 i
Davies et al. (1970)*	870	2.422 - 0.9667 i
Davies et al. (1970)	1250	2.630 - 1.1407 i

*The index of refraction for 870 μm is an interpolated value.

Table IX. Static Dielectric Constant of Water

From NSRDS-NBS 24

W. J. Hamer

t°C	ε*	ε†	t°C	ε*	ε†
0	87.74	87.90	50	69.91	69.88
5	85.76	85.90	55	68.34	68.30
10	83.83	83.95	60	66.81	66.76
15	81.95	82.04	65	65.32	65.25
18	80.84	80.93	70	63.86	63.78
20	80.10	80.18	75	62.43	62.34
25	78.30	78.36	80	61.03	60.93
30	76.55	76.58	85	59.66	59.55
35	74.83	74.85	90	58.32	58.20
38	73.82	73.83	95	57.01	56.88
40	73.15	73.15	100	55.72	55.58
45	71.51	71.50			

*From data of Malmberg and Maryott (1956).

†From data of Owen, Miller, Milner and Cogan (1961).

Table X. Complex Indices of Refraction vs Wavelength for Water

(from Ref. 25)

$m = n' + i\,n''$

λ(μm)	n"(λ)	n'(λ)
100	-0.532	1.957
110	-0.531	1.966
120	-0.526	2.004
130	-0.514	2.036
140	-0.500	2.056
150	-0.495	2.069
160	-0.496	2.081
170	-0.497	2.094
180	-0.499	2.107
190	-0.501	2.119
200	-0.504	2.130

for frequencies between 8 and 70 Ghz are presented here as Table XI. The disagreements between the two sets of refractive indices are more pronounced in the complex part, n", than in the real part, n'. Crane took the Debye index of refraction to be defined by

$$n(\lambda) = \sqrt{\frac{88 - 5.5}{1 + \frac{i \cdot \Delta\lambda(T)}{\lambda}} - 5.5} = n' + i \cdot n''$$

where $\Delta\lambda(T)$ = temperature-dependent 1/2 width. "88" is actually a temperature-dependent static dielectric constant at 0 frequency. Wilcox and Grazino[27] developed a compilation of the index of refraction of water vs temperature for λ = 1, 3, and 10 mm radiation, shown here as Table XII.

There seems to be a great amount of faith put on the use of the Debye formula for calculating the complex index of refraction of water in the microwave and millimeter wavelength range. It would be interesting to see some measured data in the 1250 μm - 1 cm wavelength region, as there was in the 12 μm - 100 μm region for Deirmendjian's report.

To help visualize better some of the previously-described tabulated measured data on the complex index of refraction for water at wavelengths between 10 and 1000 μm, several curves from Deirmendjian[22] are reproduced here as Fig. 8. Also, in Fig. 9 we present the extinction coefficient of water as given by Hale and Querry[25] (imaginary part of complex index of refraction) as a function of wavelength for wavelengths between 10^{-6} m and 1 meter. Fig. 10 shows a set of plots from Hale and Querry[25] giving the real part of the index of refraction of water for the spectral region 0.2 - 200 μm. The individual data points on each set of curves refer to individual authors data that Deirmendjian and Hale and Querry, respectively, used. For further details about these points, please consult Refs. 21, 22, and 25.

Table XI. Refractive Index of Water for a Drop Temperature of 0.0°C
(Data from Ref. 26)

Computed Using Debye Model with Kerr Coefficients

Frequency (GHz)	n'	n''
8.00	7.4786	-2.7721
9.35	7.0969	-2.9060
15.50	5.7619	-3.0278
35.00	3.9533	-2.4301
70.00	3.0179	-1.6856
Computed Using Data Attributed to Grant, et al.		
8.00	7.6474	-2.7146
9.35	7.2788	-2.8692
15.50	5.9459	-3.0694
35.00	4.055	-2.5465
70.00	3.0410	-1.8093

Table XII. Indices of Refraction for Water vs Wavelength (from data in Ref. 27)

λ(mm)	Temperature (deg C)	Index of refraction
1	0	2.407 - i0.477
	10	2.481 - i0.705
	18	2.561 - i0.885
	20	2.587 - i0.937
3	0	2.759 - i1.241
	10	3.106 - i1.663
	18	3.411 - i1.937
	20	3.505 - i2.007
10	0	4.221 - i2.526
	10	5.155 - i2.834
	18	5.817 - i2.869
	20	5.992 - i2.900

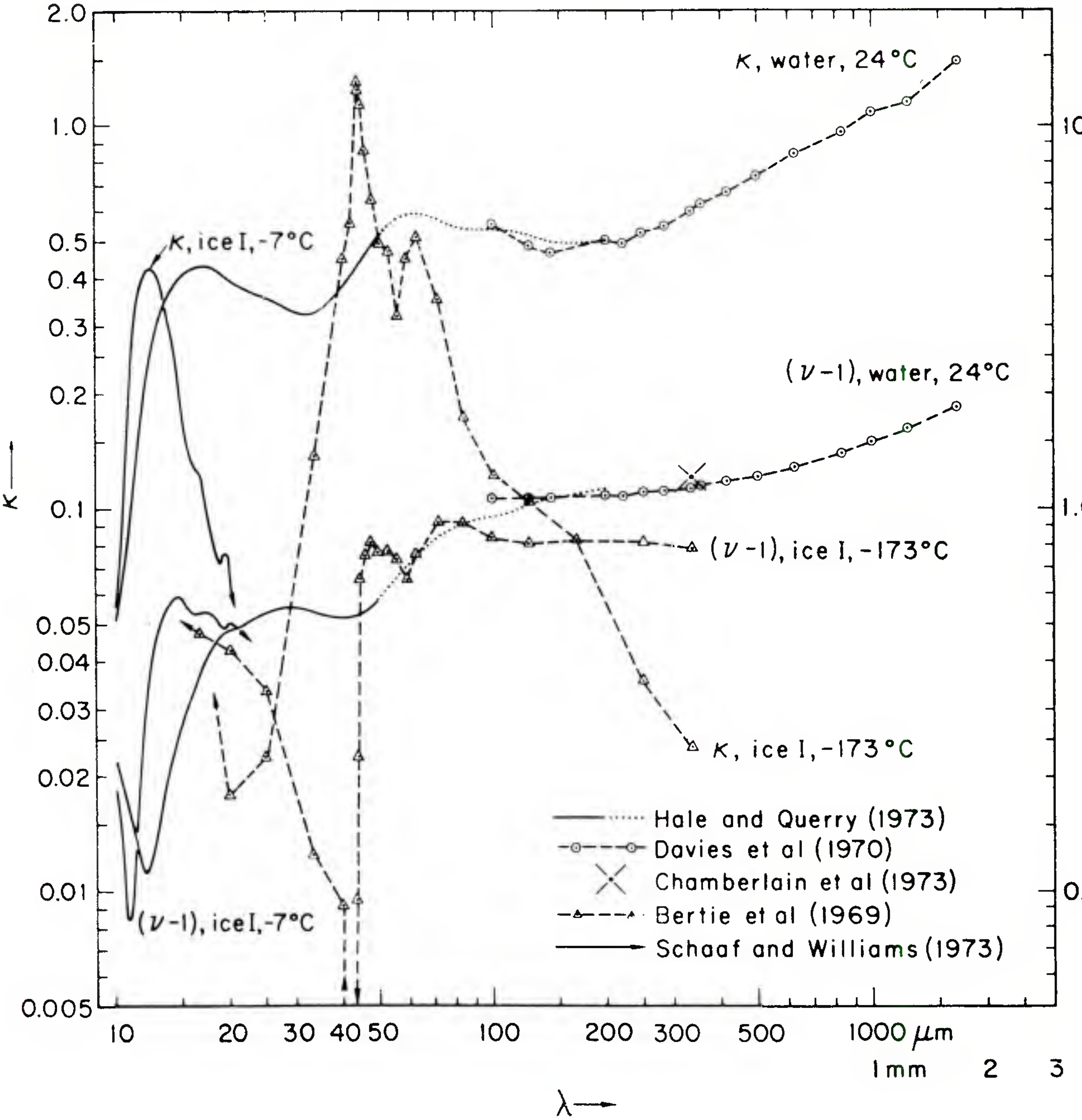


Fig. 8. Optical Constants of Water According to Recent Measurements (Data from Ref. 22)

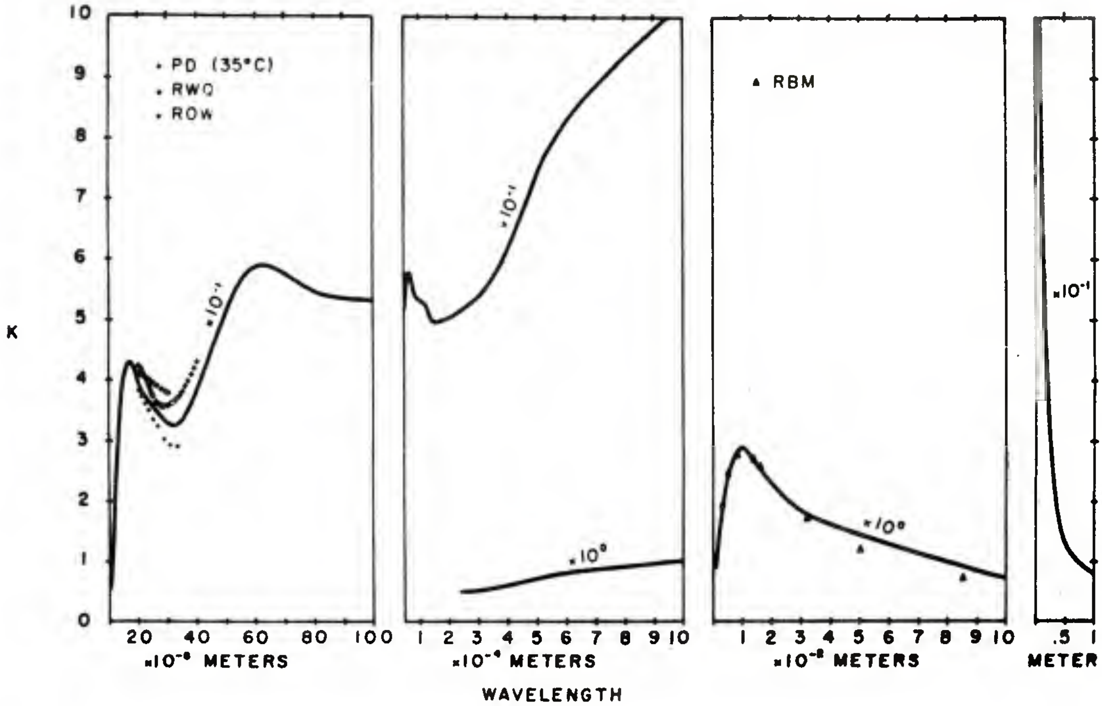


Fig. 9. Imaginary Part of the Index of Refraction of Water vs. Wavelength (from Ref. 25)

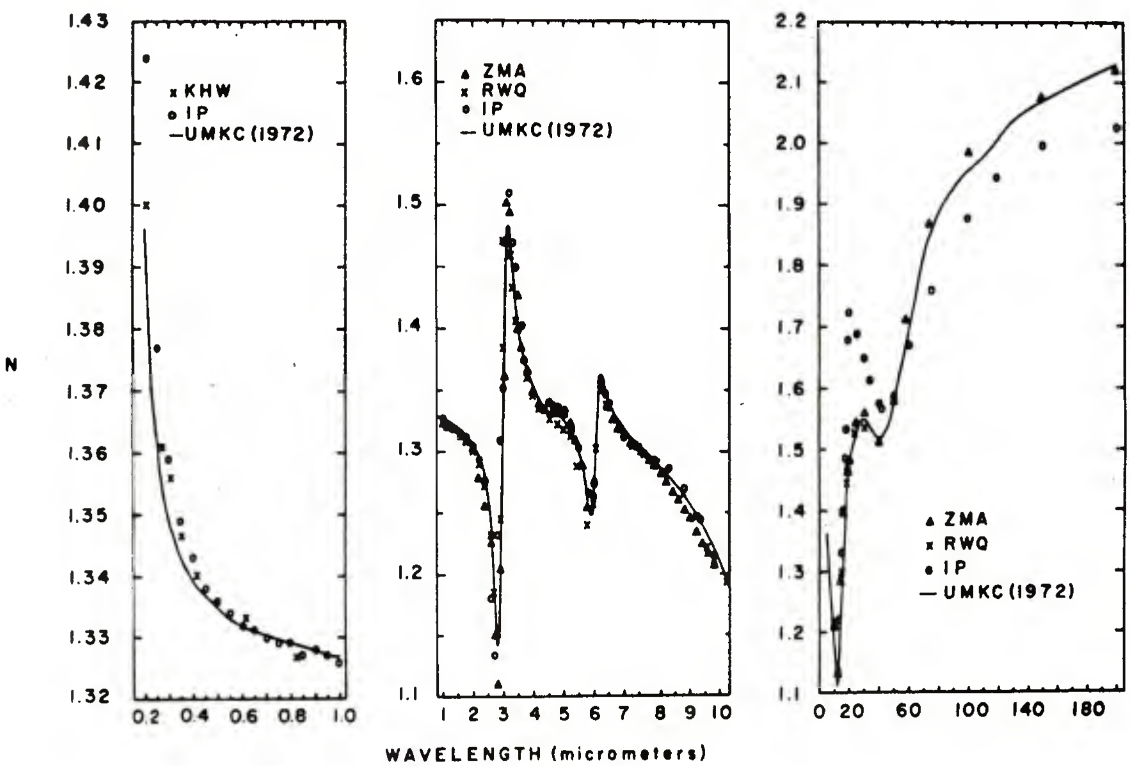


Fig. 10. Real Part of the Index of Refraction of Water vs. Wavelength (from Ref. 25)

Chamberlain, Zafer and Hasted[28] have measured the index of refraction of water between .1 mm and 0.5 mm using a Michelson interferometer. Results of their measurements, and some others they quote are shown in Fig. 11.

One needs to have indices of refraction (or the dielectric "constant", equivalently) available as a function of temperature when computing scattering, absorption and extinction cross sections with the use of Mie or Rayleigh theory.

The need for further work on the complex index of refraction for water is obvious; first in priority with respect to water is the need for experimental data on the complex index of refraction as a function of temperature over the entire wavelength range of interest. Most severe is the requirement in the 1 cm - 1 mm region where everyone seems to rely on the Debye equation with no references to actual dielectric/refractive index measurements in that spectral region.

A. Stogryn[29] has developed a modification of the Debye equation for the complex dielectric "constant" of saline water. He has given parameters in the equation as functions of water temperature and salinity. The dielectric constant is defined by

$$K = \varepsilon_\infty + \frac{\varepsilon_o - \varepsilon_\infty}{1 - i \cdot 2\tau\pi f} + \frac{i\sigma}{2\pi\varepsilon_o^* f}$$

with

ε_o = temperature- and salt-control-dependent static dielectric constant

τ = time constant as a function of temperature and normality of the salt solution = $\tau(T,N)$

f = frequency in Hertz

ε_∞ = 5.5

σ = ionic conductivity of the dissolved salt in mho/meter

ε_o^* = permittivity of free space = 8.854×10^{-12} Farad/meter.

He gave ε_o, τ, and σ as a function of the normality of the salt solution.

A relationship of this sort should be valuable in the calculation of scattering by slightly salty fogs (sea spray), or fogs that have become

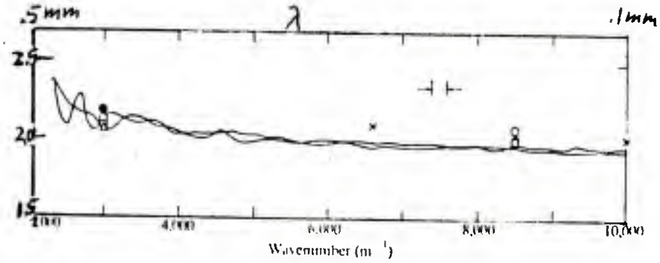


Fig. 11. Measured Values of the Real Component of the Refractive Index for Water (the full lines are from two independent measurements by the authors of Ref. 28. The points are measurements by other authors and by the authors of Ref. 28).

contaminated with ZnCl dust from smoke screens or from burning phosphorous, which forms P_2O_5, which becomes dilute phosphoric acid when the P_2O_5 contacts a fog droplet.

There are several basic texts that are of value for information on dielectrics; these are: Dielectrics and Waves, by A. R. Von Hippel,[30] Dielectric Materials and Applications,[31] by A. R. Von Hippel, and The Theory of Electric and Magnetic Susceptibilities[32]. Von Hippel's books have been the compendium of information on dielectric phenomena for 20 years. Van Vleck's treatise,[32] now 44 years old, still is one of the best introductions to dielectric and magnetic phenomena extant. Van Vleck recently[33] has written a revised version of his classic papers on line breadths and should be consulted for details as to validity of the formula presented here or by other authors regarding this area.

The principal difference between fog, rain and clouds when determining their scattering, absorption and extinction cross sections is in the range of drop diameters for each. The ranges of drop diameters for haze, fog, clouds, and rain, as given by G. D. Luhers,[34] are given in Table XIII. Note that although there is quite an overlap in drop diameters for fogs, clouds and rain, there is a tendency to larger drop diameters as the atmospheric conditions change from clouds to fog to rain.

The calculation of the absorption, scattering and extinction in a medium such as fog, clouds and rain is based on the knowledge of the absorption, scattering and extinction cross sections for individual particles. The theory for calculating these cross sections for individual spherical particles was developed by Mie.[35] Mie's work was extended by Stratton[36] and, as outlined in Kerr,[37] by Goldstein. A Comprehensive study of the theory of electromagnetic scattering from small particles is also given by Van De Hulst.[38]

A single dielectric sphere in the path of a plane wave will scatter and absorb some of the incident energy. These effects are characterized by several quantities called cross sections and have the dimensions

Table XIII. Drop Diameters for Various Atmospheric Conditions (from Ref. 34)

ATMOSPHERIC CONDITION	DROP SIZE RANGE Micrometers
Haze	0.01 - 3
Fog	0.01 - 100
Clouds	1 - 50
Drizzle (0.25 mm/hr)	3 - 800
Moderate Rain (4.0 mm/hr)	3 - 1500
Heavy Rain (16.0 mm/hr)	3 - 3000

of area. The Gunn and East[39] definitions of the scattering, absorption, extinction, and backscatter cross-sections are:

$$\underset{(Q_s)}{\text{Scattering Cross Section}} = \frac{\text{Total Power Scattered (over } 4\pi \text{ steradians)}}{\text{Incident Power Density}}$$

$$\underset{(Q_a)}{\text{Absorption Cross Section}} = \frac{\text{Total Power Absorbed (as heat)}}{\text{Incident Power Density}}$$

$$\underset{(Q_a)}{\text{Extinction Cross Section}} = \frac{\text{Total Power Lost (to the incident wave)}}{\text{Incident Power Density}}$$

The term extinction is used to describe the energy lost by the incident wave to a single particle; attenuation is the energy lost to a continuous volume of particles.

It should be noted that the conservation of energy requires that

$$Q_e = Q_a + Q_s$$

and

$$\underset{(\sigma)}{\text{Backscatter Cross Section}} = \frac{\text{Total Power Scattered Backward (along the direction of incidence)}}{\text{Incident Power Density}} .$$

The scattering and absorption properties of single particles are complex functions of the size, shape, and index of refraction of the particles as well as the wavelength of the incident energy. The scattering, absorption, extinction and backscattering cross sections for 4.3 mm wavelength radiation interaction with spherical water spheres at 18°C (from Ref. 40), are presented in Fig. 12 as a function of the particle radius. It is seen that the cross sections increase with radius for radii between 0 and 6 mm.

For mm wavelength radar our interest lies in the backscatter and attenuation cross sections associated with a continuous distribution of particle sizes within a given volume. Particle size distributions for rain, fog and clouds are given by Deirmendjian[22] and Richard.[40] If the particle size distribution is known, the reflectivity and attenuation can be determined, using the appropriate scattering theory.

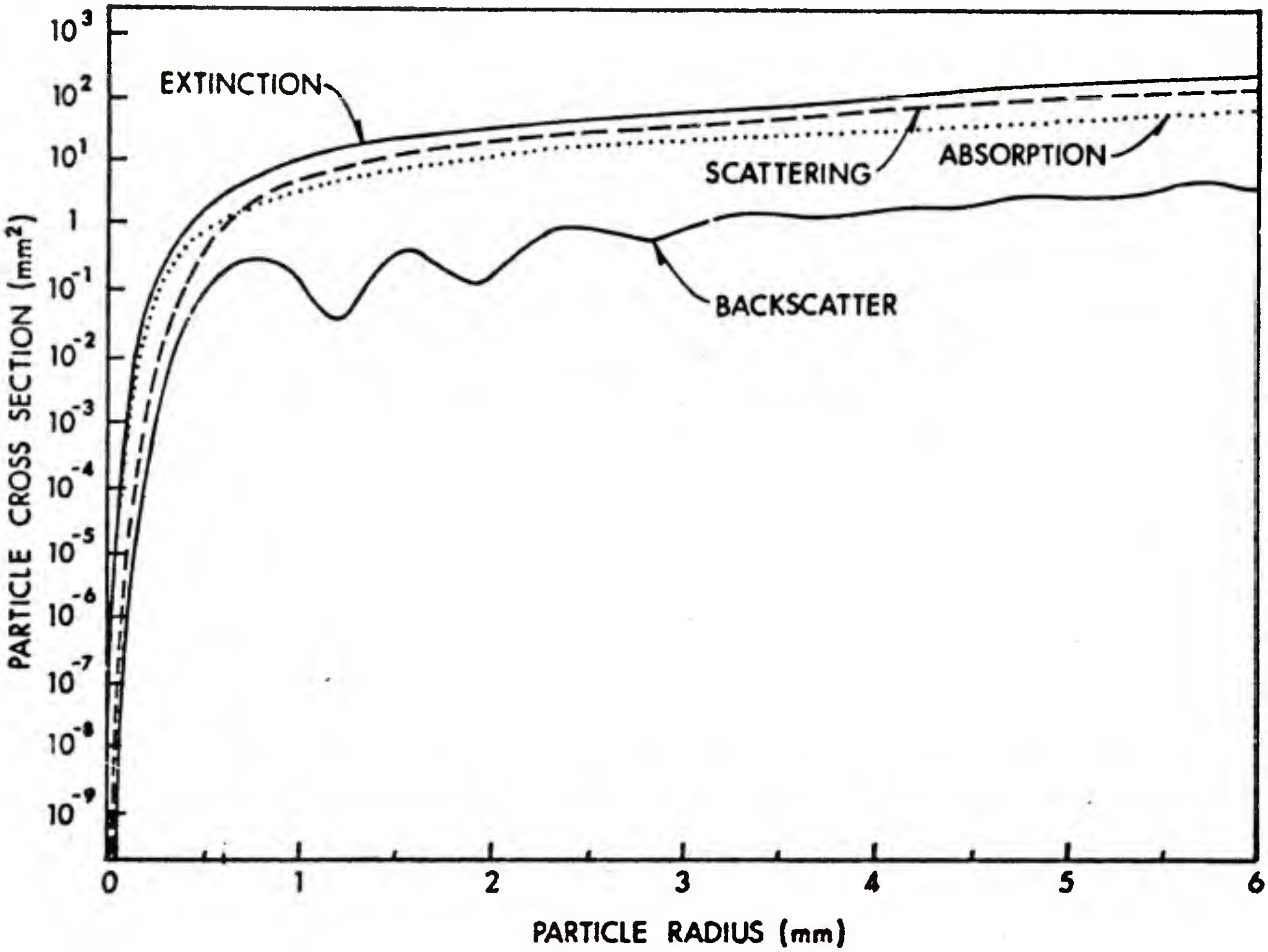


Fig. 12. Cross Sections of Water Spheres at 18°C for 4.3 mm Wavelength Energy (from Ref. 40)

The scattering theory to be used in the determination of the backscatter and attenuation of rain and fog depends on the size of the drops in the medium and the wavelength of the radiation. Mie scattering theory must be used for drops larger than 0.06 wavelength in diameter. For drops smaller than 0.06 wavelength the Rayleigh theory approximations are applicable.

Since rain is comprised of drops 258 micrometers (0.258 mm) and larger, Mie scattering theory must be used for millimeter wavelength radiation. The smaller drops in haze, fog and clouds allow the use of the Rayleigh approximation.

Fog results from the condensation of atmospheric water vapor into water droplets that remain suspended in the air. When the resulting cloud or water droplets or ice crystals envelop an observer and restrict his horizontal visibility to one kilometer or less, the international definition of fog has been satisfied. Evaporation and cooling are the principal physical processes which contribute to the formation of fog. Of the various fog classifications used by meteorologists, the two basic types of interest in radar applications are advection fog and radiation fog.

Advection is the horizontal movement of an air mass that causes changes in temperature or other physical properties. An advection (or coastal) fog is one which forms over open water as a result of the advection of warm moist air over colder water.

Radiation (or inland) fog forms in air that has been over land during the daylight hours preceding the night of its formation. Fogs which form in low, marshy land and along rivers on calm, clear nights are also considered radiation fogs.

The characteristics of these two fogs are given in Table XIV.

Note that the advection fog has a higher liquid water content, but greater visibility than the radiation fog. The correlation of visibility in fog to liquid water content is shown in Fig. 13 (from

Table XIV. Fog Characteristics
(Data from Ref. 40)

	RADIATION (INLAND) FOG	ADVECTION (COASTAL) FOG
Average Drop Diameter	10 microns	20 microns
Typical Drop Size Range	5-35 microns	7-65 microns
Liquid Water Content	0.11 g/m^3	0.17 g/m^3
Droplet Concentration	200 cm^{-3}	40 cm^{-3}
Visibility	100 m	200 m

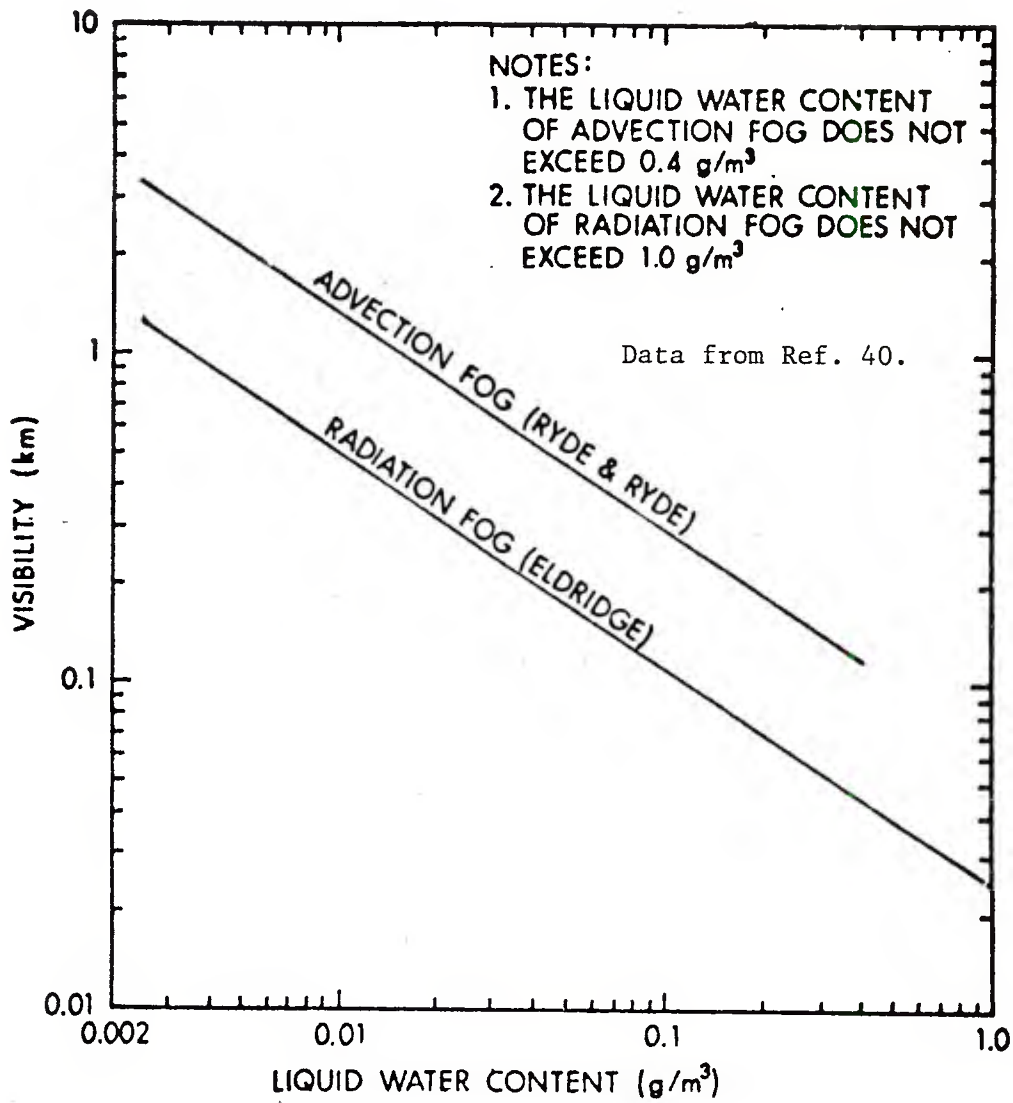


Fig. 13. Correlation of Visibility in Fog to Liquid Water Content

Ref. 40) for both advection and radiation fogs.

There is considerable variation in the water content of clouds and water fogs, but in general, stratus (or low) clouds and typical radiation or advection fogs have water contents on the order of 0.25 g/m^3 or less. Mason[41] reports that the maximum liquid water content of an advection fog approaches 0.4 g/m^3 when there is a strong temperature inversion. On rare occasions, the liquid water content can become as large as 0.5 to 1.0 g/m^3 in very dense radiation fogs (with 20 to 30 meters visibility).[42]

The small size of water droplets comprising a fog allows the use of the Rayleigh approximations in the determination of the reflectivity and attenuation at 70 GHz. Atlas[43] shows that in the Rayleigh scattering region the one-way attenuation coefficient, α, is given by

$$\alpha = \frac{81.86 \text{ M Im}(-K)}{\lambda\rho} \text{ dB/km},$$

where M = liquid water content per unit volume of fog in g/m^3,

$\text{Im}(-K)$ = absorption coefficient,

$K = \frac{m^2-1}{m^2+2}$,

m = complex index of refraction,

λ = wavelength in mm,

ρ = density of water in g/cm^3.

A density of 1 g/cm^3 for water is generally assumed for all temperatures, since the density varies no more than 0.78% over the 0°C to 40°C temperature range.

In the Rayleigh scattering region, attenuation is due mainly to absorption. To calculate the absorption coefficient for fog, the index of refraction for water must be determined for the frequencies of interest. The complex index of refraction, m, is given in terms of the complex dielectric constant, ε_c, by:

$$m^2 = \varepsilon_c = \varepsilon_1 - j\varepsilon_2,$$

where ε_1 and ε_2 are the real and imaginary parts of the dielectric constant.

The dielectric constant may be evaluated by the Debye formula[37]

$$\varepsilon_c = \frac{\varepsilon_o - \varepsilon_\infty}{1 + j\,\frac{\Delta\lambda}{\lambda}} + \varepsilon_\infty,$$

where ε_o, ε_∞ and $\Delta\lambda$ are empirically derived constants.

Let us now look at some of the data currently available on millimeter and submillimeter wavelength attenuation in fog, clouds, and rain. Victor W. Richard, in Ref. 40, has given a good description of rain, fog and cloud data, from which a lot of this section's information is derived. A summary of the data from Richard[40] is presented in Figs. 14 and 15. Fig. 14 shows the positions of the atmospheric "windows", and the "walls". The profitable areas for further work in the millimeter-submillimeter region apparently should center around wavelengths of 94 GHz, 140 GHz, 240 GHz, 360 GHz, 420 GHz, and 890 GHz. Past 240 GHz, long-range communications do not appear to be practical; however, short range uses as missile guidance radar and imaging, target designators, and others, should be feasible. Fig. 15 is a comparison of the one-way attenuation due to a fog of 100 m visibility having a density of 0.1 gm/m^3 with the one-way attenuation for 3 rain rates as a function of frequency. Fig. 16 (Ref. 40) shows in more detail the one-way attenuation of a fog as a function of frequency, temperature and liquid water content. A. R. Downs[44] has calculated haze and fog attenuation coefficients for visible and IR radiation, as well as for microwaves with frequencies between 9.375 to 240 GHz. These data are shown on Table XV. Downs' article references 27 different papers on atmospheric transmission on rain, fog and battlefield dust conditions.

Dorothy Stewart[45] in her extensive literature search on fogs and their drop sizes, has computed the extinction of visible, IR, and

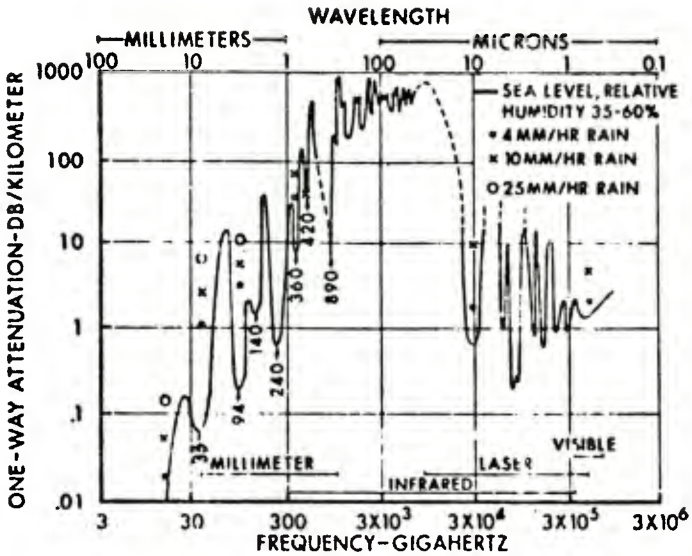


Fig. 14. Atmospheric Attenuation vs. Frequency (from Ref. 40)

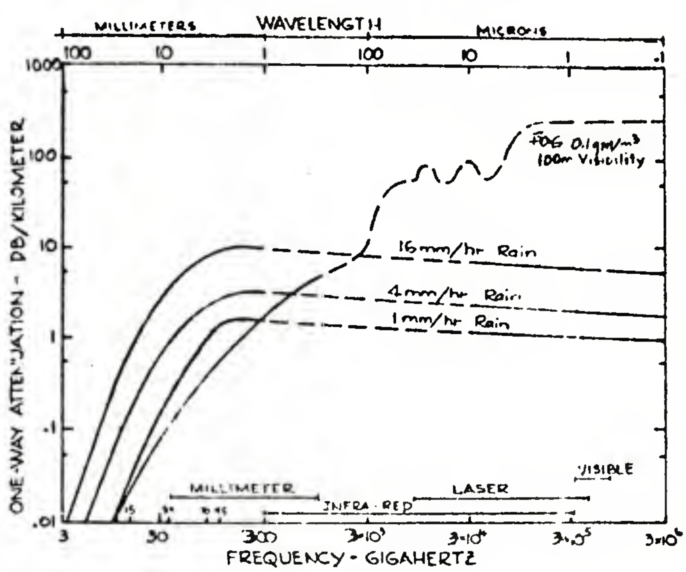


Fig. 15. Rain and Fog Attenuation vs. Frequency (from Ref. 40)

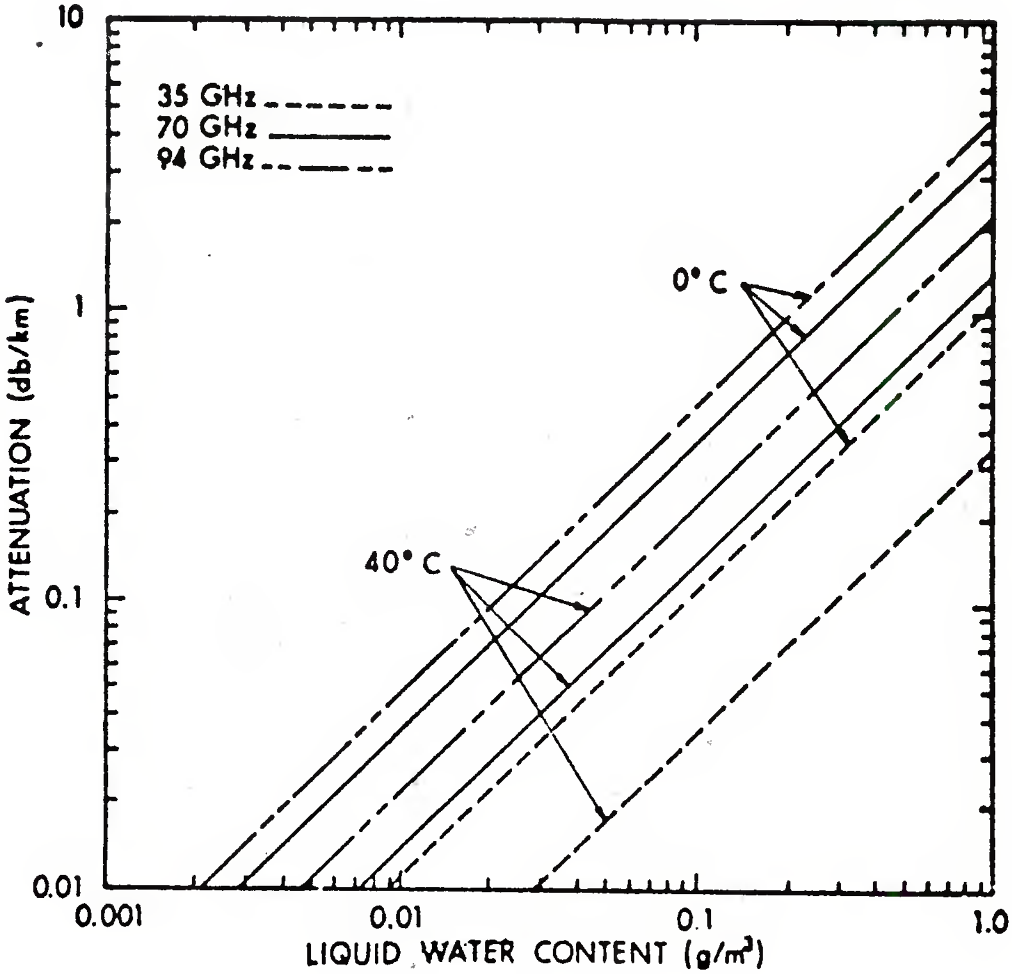


Fig. 16. One-Way Attenuation in Fog As a Function of Liquid Water Content (from Ref. 40)

Table XV. Haze and Fog Attenuation Coefficients as a Function of Visibility and Wavelength (from Ref. 44)

VISIBILITY (KM)	HAZE AND FOG ATTENUATION COEFFICIENTS (KM^{-1})									
	WAVELENGTH (MICRONS)					FREQUENCY (GHZ)				
	0.56	1.06	2.3	3.8	10.6	9.375	35	94	140	240
0.1	3.8×10^{1}	3.8×10^{1}	3.8×10^{1}	4.0×10^{1}	1.3×10^{2}	0	1.6×10^{-2}	4.4×10^{-2}	3.2×10^{-1}	1.4×10^{-1}
0.2	2.2×10^{1}	2.2×10^{1}	2.1×10^{1}	2.0×10^{1}	6.5×10^{1}					
0.5	9.5×10^{0}	9.6×10^{0}	8.7×10^{0}	7.1×10^{0}	1.7×10^{1}					
1.0	4.8×10^{0}	4.8×10^{0}	4.4×10^{0}	3.5×10^{0}	4.4×10^{0}					
2.0	2.2×10^{0}	2.2×10^{0}	1.9×10^{0}	1.6×10^{0}	1.2×10^{0}					
5.0	9.5×10^{-1}	9.5×10^{-1}	8.5×10^{-1}	6.6×10^{-1}	3.1×10^{-1}					
10.0	4.8×10^{-1}	4.8×10^{-1}	4.2×10^{-1}	3.3×10^{-1}	1.7×10^{-1}					
20.0	2.4×10^{-1}	2.4×10^{-1}	2.1×10^{-1}	1.6×10^{-1}	9.4×10^{-2}					
50.0	9.5×10^{-2}	9.5×10^{-2}	8.3×10^{-2}	6.1×10^{-2}	6.7×10^{-2}					
326.0	1.2×10^{-2}	8.2×10^{-4}	3.7×10^{-5}	5.0×10^{-6}	8.0×10^{-8}					

submillimeter energy by fogs. Results of her calculations are shown in Figs. 17, 18, and 19. Fig. 17 shows a comparison of the attenuation of 1250 μm and 10.5 μm radiation by fog droplets; Fig. 18 shows a comparison of the attenuation of 1250 μm and 0.55 μm radiation by fog droplets; and Fig. 19 shows a comparison of the attenuation of 1250 μm and 870 μm radiation by fog droplets. We see from Fig. 18 that the visibility at .55 μm is not necessarily a good indicator of 1250 μm attenuation, but that the correlation of 10.6 and 1250 μm attenuation is pretty good. Also, the correlation of attenuations of 870 μm and 1250 μm radiation is good.

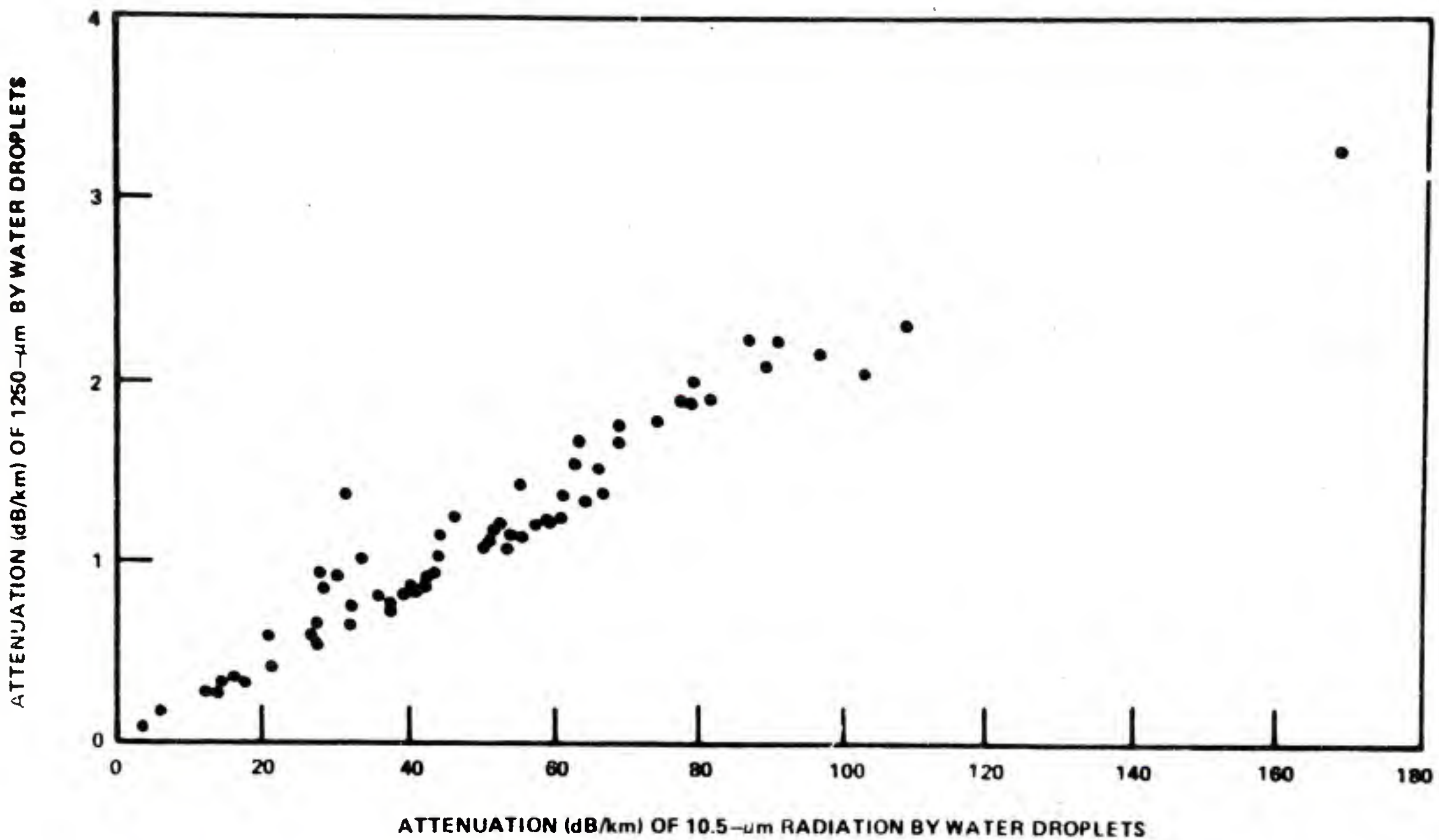


Fig. 17. Comparison of Attenuation of 1250- and 10.5-μm Radiation by Fog Droplets (from Ref. 45)

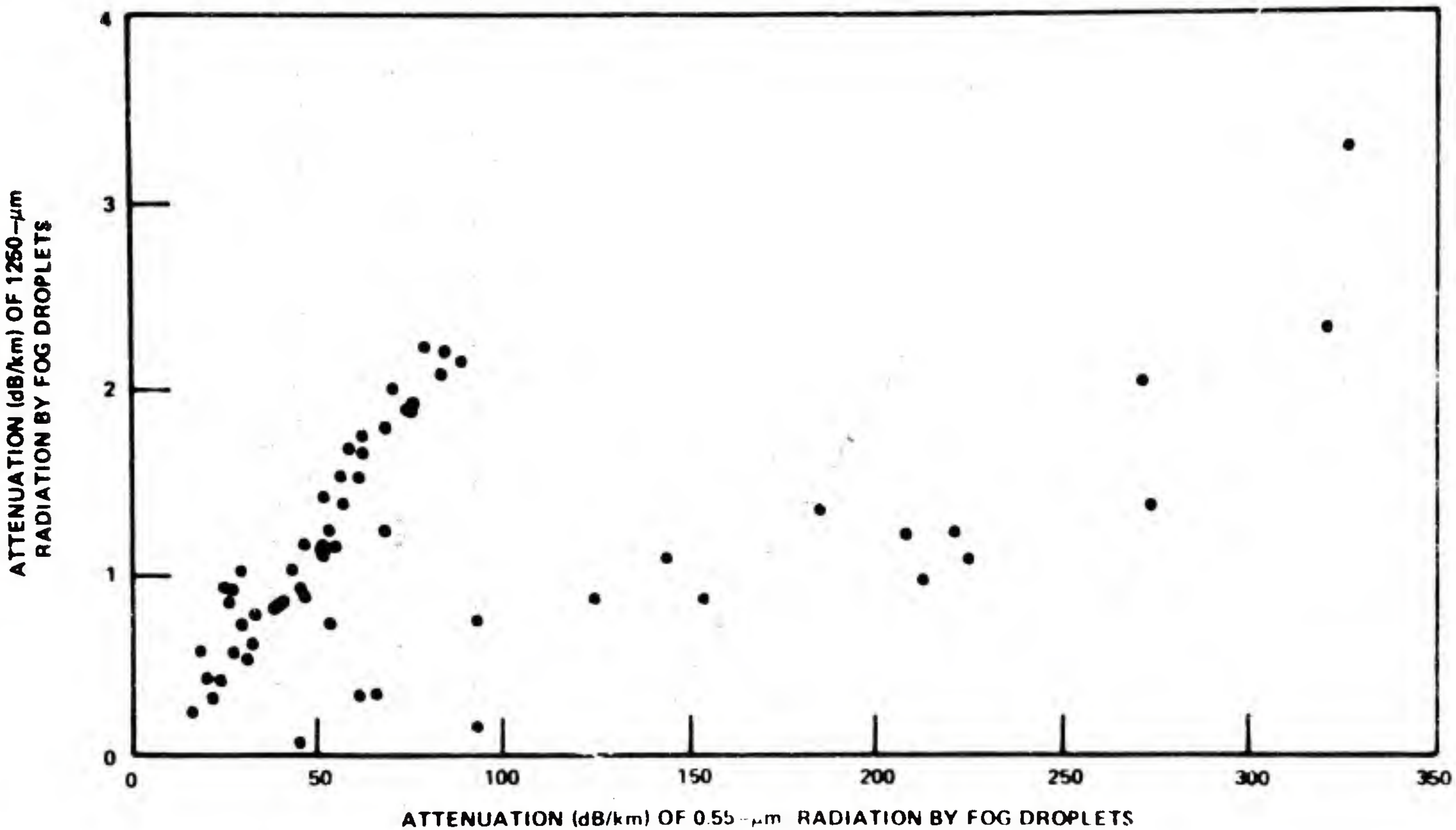


Fig. 18. Comparison of Attenuation of 1250- and 0.55-μm Radiation by Fog Droplets (from Ref. 45)

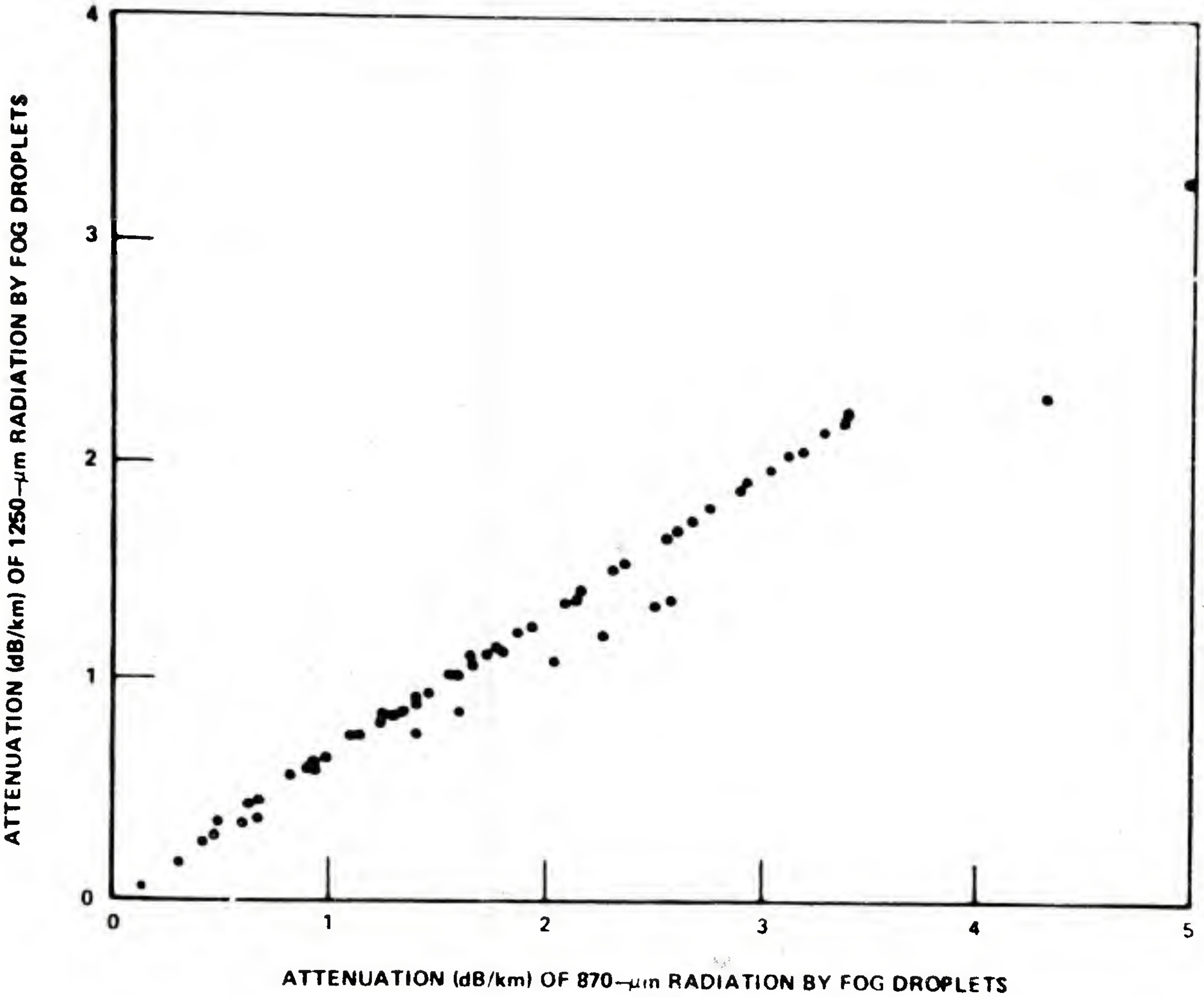


Fig. 19. Comparison of Attenuation of 1250- and 870-μm Radiation by Fog Droplets. (data from Ref. 45)

Downs[44] calculated the scattering coefficient for haze and fog at millimeter wavelengths and concluded that the scattering coefficient was between 10^{-4} and 10^{-5} (km^{-1}) which is at least 6 orders of magnitude below that of the scattering coefficients for haze and fogs at wavelengths of .55 μm - 10.6 μm.

V. Corcoran[46] has calculated the fraction of the total attenuation along a zenith path through the atmosphere containing a 500-m thick strato-cumulus cloud that results from the water droplets in the cloud and from the gaseous absorption along the total path. It is seen from Table XVI that the contribution to the attenuation by cloud droplets increases with an increase in the wavelength for wavelengths between 0.345 mm and 3 mm. Similarly the contribution to the attenuation by gaseous absorption increases with a decrease in wavelength. The attenuation resulting from gaseous absorption is seen in Table XVI to increase faster with decreasing wavelength than does the attenuation produced by the cloud droplets.

D. Deirmendjian[22] has calculated extinction coefficients according to 3 cloud models and 2 precipitation models; his results are shown in Fig. 20. His calculations were for wavelengths between 1.0 μm to 100 mm. Tabulated values of this data are presented in Table XVII. Deirmendjian has also calculated a set of mass extinction coefficients for haze, clouds, and rain; this data are presented in Table XVIII for discrete wavelengths between 16 μm to 2.0 mm.

Lo, Fannin and Straiton[47] have measured "the attenuation of 8.6 and 3.2 mm radio waves in clouds" by use of a millimeter wave radiometer. Results of their measurements are shown in Figs. 21, 22, and 23. Corrections were made to the measured data for the attenuation resulting from the atmosphere gaseous constituents to obtain estimates of the cloud attenuations. The correction for water vapor attenuation was based on ground-level water vapor density measurements. The sum was used as a source of millimeter wavelength radiation with the radiometer pointing at it through the clouds. Figure 21 presents 35 GHz (8.6 mm) attenuation vs 95 GHz (3.2 mm) attenuation for heavy pre-rain clouds. Figure 22 presents the total (zenith) attenuation due to cumulus clouds for 92

Table XVI. Proportion of Total Attenuation Due to a 500-m Strato-Cumulus Cloud in a Zenith Path (data from Ref. 46)

Candidate windows		Total gaseous absorption	Contribution by droplets in a 500-meter st-cu cloud	Total attenuation due to gases and cloud droplets	Proportion of total attenuation due to cloud droplets
Window	Wavelength λ				
III	3mm	1.25 db	0.97 db	2.22 db	43.7%
IV	2.3mm	0.91 db	1.17 db	2.08 db	56.2%
V	1.3mm	2.11 db	1.60 db	3.71 db	43.2%
VI	880μ	9.87 db	2.40 db	12.27 db	19.6%
VII	720μ	22.0 db	2.92 db	24.92 db	11.7%
IX	620μ	57.0 db	3.00 db	60.0 db	5.0%
XII	345μ	77.0 db	5.50 db	82.5 db	6.7%

Table XVII. Cloud Volume Extinction and Absorption Coefficients (data from Ref. 22)

(Neper km^{-1})

	Cloud C.1 ($N = 10^2 cm^{-3}$)		Cloud C.5 ($N = 10^2 cm^{-3}$)		Cloud C.6 ($N = 10^{-1} cm^{-3}$)	
λ	β_{ex}	β_{ab}	β_{ex}	β_{ab}	β_{ex}	β_{ab}
(λ→0)	(15.64)		(42.41)		(0.7540)	
12.μm	10.28	7.352	36.32	22.61	0.7933	0.4030
17.μm	16.12	10.23	49.98*	28.49*	0.8500*	0.4113*
28.μm	12.33	7.849	49.88	27.36	0.9004	0.4521
40.μm	8.468	6.392	39.86	24.89	0.9250	0.4774
60.μm	7.013	5.816	37.69	25.41	0.9742	0.5065
100.μm	2.690	2.415	20.70	14.55	1.061	0.553
140.μm	1.420	1.352	9.742	7.797	1.074	0.555
200.μm	0.9732	0.9570	5.617	5.109	0.9774	0.5190
337.μm	0.5812	0.5789	2.949	2.880	0.6845	0.4016
500.μm	0.4566	0.4560	2.235	2.219	0.4186	0.2911
700.μm	0.3474	0.3472	1.676	1.671	0.2563	0.2031
1000.μm		(0.2423)	1.165	1.164	0.1440	0.1274
2.mm		(0.0999)		(0.474)		(0.0401)
5.mm		(0.0381)		(0.181)		(0.0153)
10.mm		(0.0119)		(0.0563)		(0.0048)

*Values from an earlier run with m = 1.369 - 0.438i.

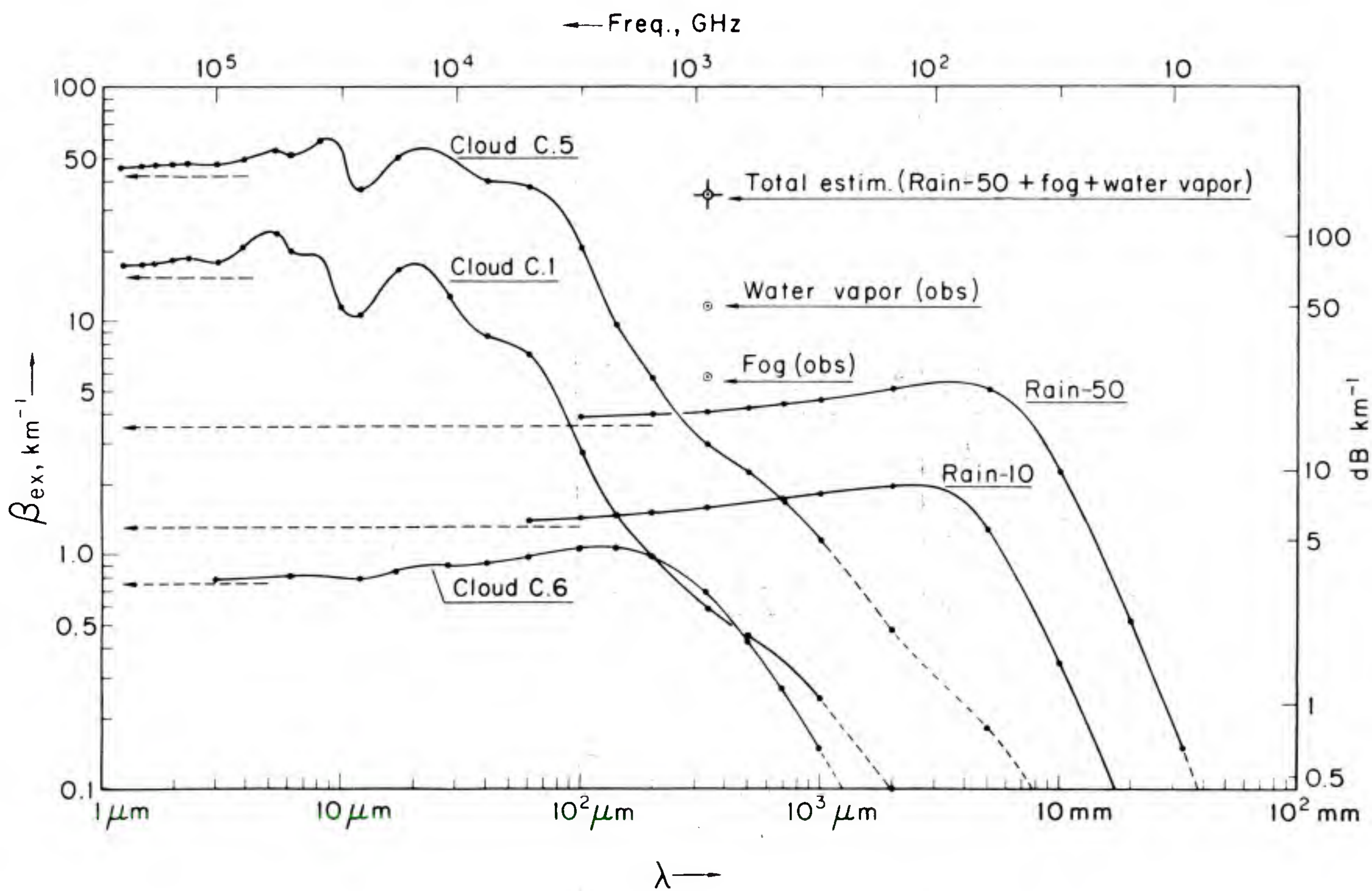


Fig. 20. Theoretical Extinction Coefficients According to Three Cloud Models and two Precipitation Models (data from Ref. 22)

Table XVIII. Mass Extinction Coefficients for Haze, Clouds, and Rain (data from Ref. 22)

(γ_{ex} in neper km^{-1} per g m^{-3} liquid water content)

λ	Haze L $w = 1.167 \cdot 10^{-5}$ g m^{-3}	Cloud C.1 $w = 0.06255$ g m^{-3}	Cloud C.5 $w = 0.2969$ g m^{-3}	Rain-10 $w = 0.5091$ g m^{-3}
($\lambda \to 0$)	(3117.)	(250.1)	(142.8)	(2.573)
16.6μm	247.6			
17.0μm		257.8	168.3	
100.μm	(36.8)	43.01	69.72	2.816
200.μm	(16.8)	15.56	18.92	2.950
337.μm	(10.5)	9.293	9.932	3.097
500.μm	(7.21)	7.301	7.527	3.243
1.mm	(3.87)	(3.87)	3.924	3.580
2.mm	(1.60)	(1.60)	(1.60)	3.830

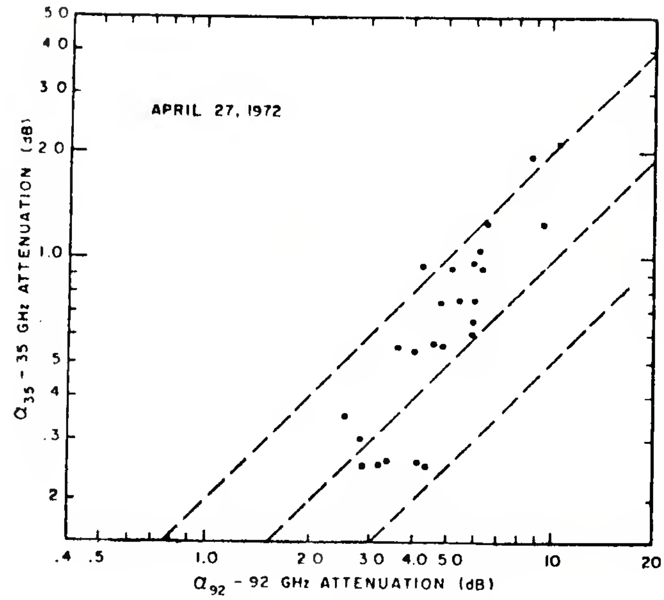


Fig. 21. 35 GHz Attenuation versus 95 GHz Attenuation for Heavy Prerain Clouds (data from Ref. 47)

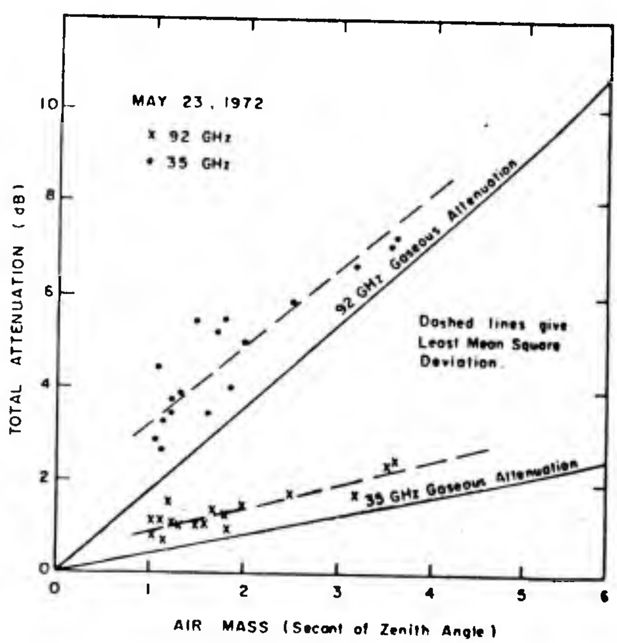


Fig. 22. Effect of Cumulus Clouds on Attenuation (data from Ref. 47)

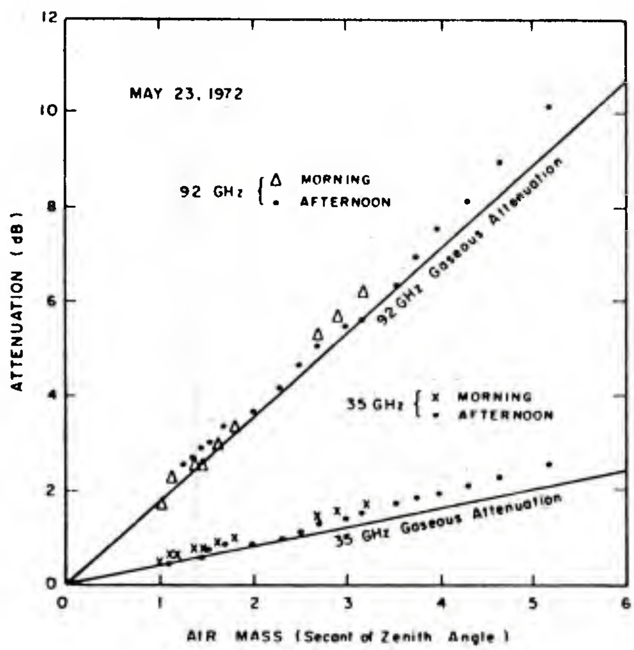


Fig. 23. Attenuation of General Overcast versus Air Mass for 35 GHz and 92 GHz (data from Ref. 47)

and 35 GHz radiation. Figure 23 shows the attenuation effects of an overcast sky versus air mass (secant of zenith angle) for 35 GHz and 92 GHz radiation.

As a function of cloud type, Lo[47] et al. have summarized their measurements in two tables: the first, presented here as Table XIX gives the attenuation in db, for 35 and 95 GHz radiation, due to individual fair-weather cumulus clouds. In Table XX is a summary of zenith cloud attenuation for 35 and 95 GHz radiation by different cloud types.

Corcoran[46] has calculated data on the attenuation due to moderate rain of a 2-km depth (zenith path through a 500 m thick strato cumulus cloud). His data for attenuation of radiation with wavelengths in the atmosphere windows between 345 μm to 3 mm are given in Table XXI.

There is a vast literature on the scattering and attenuation of millimeter and submillimeter radiation by rain. Before we get into the data and calcualtions that were found relevant, let us discuss some of the currently used size distributions for rain droplets. D. Deirmendjian[22] introduced a general raindrop sized distribution,

$$n(r) = ar^{\alpha} \exp(-br^{\gamma})$$

to model both clouds, hazes and raindrops. The parameters a, α, b, γ are positive, real numbers that may be related to measurable parameters. For $\gamma = 1$,

$$\int_0^{\infty} n(r)dr = N = \text{total number of particles per unit volume}$$

in the distribution. This gives

$$a = \frac{Nb^{\alpha+1}}{\Gamma(\alpha+1)} .$$

Some other properties of Deirmendjian's distribution are that there is only one peak in the distribution, there is exponential decay in the number density in both increasing drop size and a cut-off on decreasing drop size.

Table XIX. Attenuation due to Individual Fair Weather Cumulus Clouds (from Ref. 47)

Cloud Attenuation, dB 35 GHz	95 GHz	95 GHz Attenuation / 35 GHz Attenuation
0.16	0.88	5.5
0.04	0.18	4.5
0.12	0.65	5.4
0.06	0.22	3.7
0.09	0.36	4.0
0.16	0.48	3.0
0.04	0.16	4.0
0.06	0.22	3.7

Table XX. Summary of Zenith Cloud Attenuation for Different Cloud Types (from Ref. 47)

Cloud Type	Number of Days	Total Number of Observations	Ground Level Water Vapor Density in g/m^3 Mean	Standard Deviation	35 GHz Value in dB/95 GHz Value in dB: Measured Cloud Attenuation Mean	Standard Deviation	Calculated Gaseous Attenuation Mean	Standard Deviation
Altocumulus	5	7	16.8	1.43	.02/-.23	.09/.30	.38/1.93	.02/.14
Altostratus	2	2	14.7	1.53	.15/.30	.04/.05	.34/1.73	.03/.16
Stratocumulus	8	22	18.9	1.68	.18/.61	.13/.41	.43/2.14	.03/.15
Stratus	5	8	19.1	2.30	.13/.12	.03/.24	.42/2.14	.04/.21
Nimbostratus	2	5	20.8	0.31	.14/.11	.06/.24	.44/2.32	.01/.03
Cumulus	13	20	18.7	1.81	.12/.34	.14/.36	.41/2.12	.03/.18
Cumulonimbus	2	6	18.1	2.39	.34/2.36	.22/1.86	.40/2.07	.04/.23

Table XXI. Proportion of Total Attenuation due to Moderate Rain of 2-KM Depth (Zenith Path Through 500-M Strato-Cumulus Cloud) (data from Ref. 46)

Candidate windows		Total gaseous absorption plus contribution to attenuation by 500-meter st-cu cloud	Contribution by moderate rain of 2 km depth	Total attenuation due to gases, cloud and rain	Proportion of total attenuation due to 2 km rain
Window	Wavelength				
III	3mm	2.22 db	5.2 db	7.42 db	70%
IV	2.3mm	2.08 db	2.5 db	4.58 db	55%
V	1.3mm[a]	3.71 db	2.5 db	6.21 db	40%
VI	880μ[a]	12.27 db	2.4 db	14.67 db	16%
VII	720μ[a]	24.92 db	2.3 db	27.22 db	8%
IX	620μ[a]	60.0 db	(2.2) db	(62.2) db	(3.5)
XII	345μ[a]	82.5 db	(2.0) db	(84.5) db	(2.3)

[a]No allowance made at these wavelengths for possible reduction in attenuation due to moderate rain by the mechanism of forward scatter.

Note: Values in parentheses are extrapolated.

Other prominently used drop-size distributions are those attributed to Laws and Parson[49], Marshall and Palmer[50] and Best.[51] These distributions are illustrated by the following tables and graphs. Table XXII shows, for the Laws and Parson drop-size distribution, the percent of the total of water versus the particle size for 5 different rain rates. Similar data for the Marshall and Palmer distribution are shown in Table XXIII. The data in Tables XXII and XXIII were obtained from a paper by Wilcox and Graziano.[52] Figure 24 shows data based on the Best model that gives the drop radius concentration as a function of droplet radius for rainfall rates of 1, 4, 16, and 64 mm/hr. The Best model describes the fraction of the total liquid water contained in the water drops which have diameters less than x (mm) for a given rainfall rate R (mm/hr). The Best model is defined by:

$$F(x) = 1-\exp[-(x/a)^n] ,$$

where $a = AxR^p$.

The total liquid water content expressed in mm^3/m^3 is

$$w = CxR^r$$

$A = 1.3$, $c = 60$, $p = 0.232$, $r = 0.846$, and $n = 2.25$.

Downs[44] felt that the Best distribution most accurately describes the 70 GHz scattering data for rain. He calculated a rain scattering coefficient as a function of rainfall rate (or visibility) for visible light, IR, microwaves and millimeter wave radiation. Downs used the Laws and Parson's drop radius distribution in calculating the microwave and millimeter wave rain scattering coefficients. Downs' results are depicted in Tables XXIV and XXV. Table XXIV gives the rain scattering coefficient in km^{-1} vs visibility (or rainfall rate) for visible through 10.6 μm radiation, and Table XXV gives the rain scattering coefficient per km vs rainfall rate for frequencies of 9.375 GHz through 240 GHz. Absorption coefficients in rain for 9.375 GHz to 240 GHz radiation were calculated by Setzer;[53] his results are shown here as Table XXXVI.

Table XXII. Laws and Parsons Drop Size Distributions (data from Ref. 52)

D(mm)	Rain rate (mm/hr) 1.25	2.5	5	25	100
	Percent of total volume				
0.5	10.9	7.3	4.7	1.7	1
1	37.1	27.8	20.3	7.6	4.6
1.5	31.3	32.8	31.0	18.4	8.8
2	13.5	19	22.2	23.9	13.9
2.5	4.9	7.9	11.8	19.9	17.1
3	1.5	3.3	5.7	12.8	8.4
3.5	0.6	1.1	2.5	8.2	15
4	0.2	0.6	1	3.5	9
4.5		0.2	0.5	2.1	5.8
5			0.3	1.1	3
5.5				0.5	1.7
6				0.3	1
6.5					0.7

Table XXIII. Marshall and Palmer Drop Size Distribution (data from Ref. 52)

D(mm)	Rain rate (mm/hr) 1.25	2.5	5.0	25	100
	Percent of total volume				
0.5	85.9	81.6	76.6	65.0	54.3
1	12.1	15.0	17.8	22.9	24.8
1.5	1.7	2.8	4.3	7.9	11.5
2	0.3	0.5	1	2.8	5.2
2.5		0.1	0.3	1	2.4
3				0.4	1.1
3.5					0.5
4					0.2
4.5					
5					

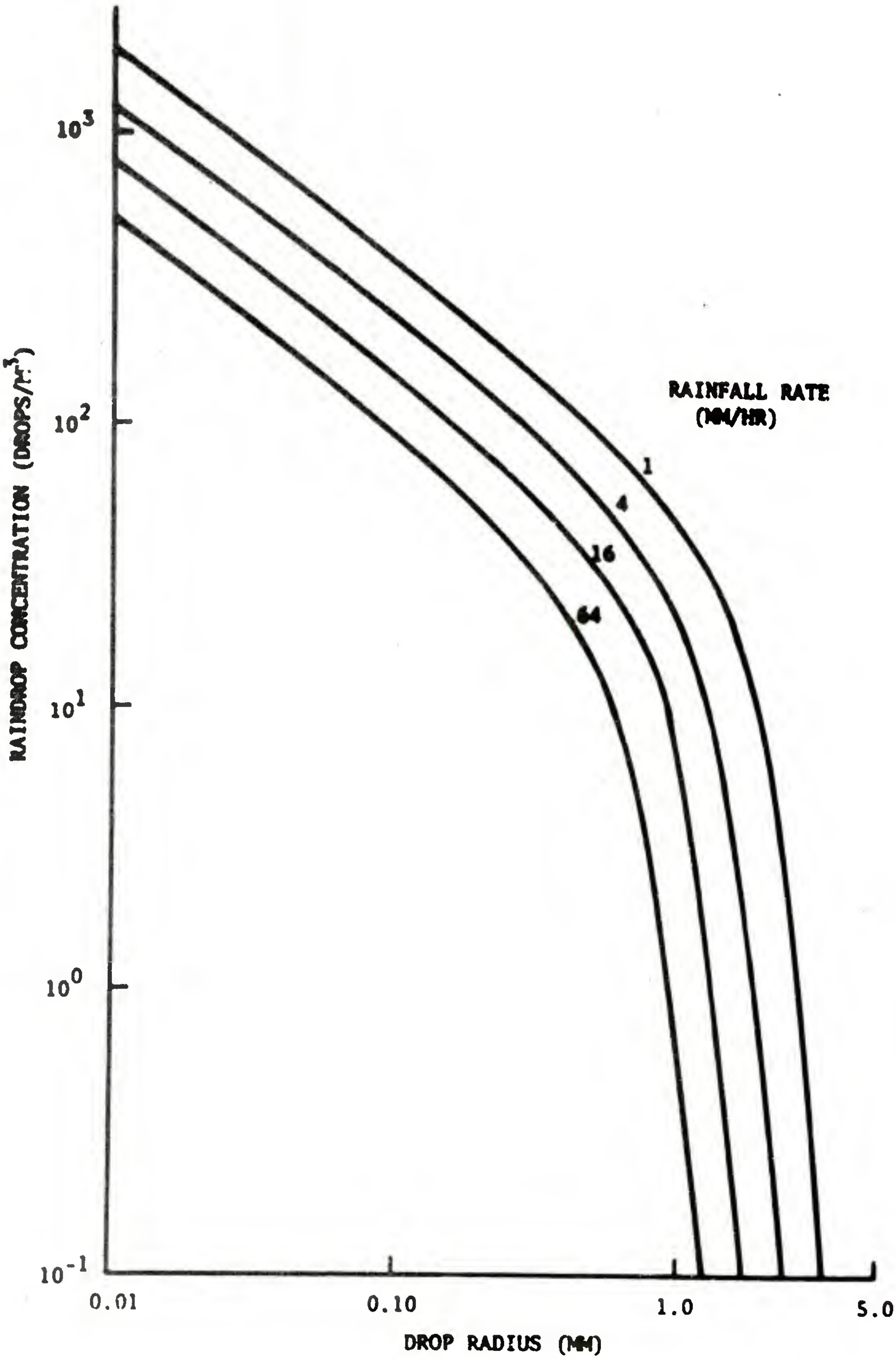


Fig. 24. Best Model for Drop Radius Distribution as a Function of Rainfall Rate (from data in Ref. 52)

Table XXIV. Scattering Coefficient for Rain as a Function of Rain Rate (or Visibility) for Wavelengths of 0.55, 1.06, 2.3, 3.8 and 10.6 μm (Data from Ref. 44)

RAINFALL RATE (MM/HR)	RAIN SCATTERING COEFFICIENT (KM^{-1}) WAVELENGTH (MICRONS)					VISI-BILITY (KM)
	0.55	1.06	2.3	3.8	10.6	
1	0.245	0.245	0.246	0.246	0.249	16.0
2	0.376	0.376	0.376	0.377	0.381	10.4
4	0.576	0.576	0.576	0.577	0.582	6.8
8	0.882	0.882	0.882	0.883	0.890	4.4
16	1.35	1.35	1.35	1.35	1.36	2.9
32	2.07	2.07	2.07	2.07	2.07	1.9
64	3.17	3.17	3.17	3.17	3.18	1.2

Table XXV. Scattering Coefficient for Rain as a Function of Rain Rate for Frequencies of 9.375, 35, 94, 140 and 240 GHz (Data form Ref. 44)

RAINFALL RATE (MM/HR)	RAIN SCATTERING COEFFICIENT (KM^{-1}) FREQUENCY (GHz)				
	9.375	35	94	140	240
1	$6.0x10^{-5}$	$1.7x10^{-2}$	$1.4x10^{-1}$	$1.6x10^{-1}$	$1.6x10^{-1}$
2	$1.7x10^{-4}$	$4.0x10^{-2}$	$2.3x10^{-1}$	$2.4x10^{-1}$	$2.4x10^{-1}$
4	$4.7x10^{-4}$	$8.5x10^{-2}$	$3.7x10^{-1}$	$3.8x10^{-1}$	$3.8x10^{-1}$
8	$1.4x10^{-3}$	$1.8x10^{-1}$	$6.4x10^{-1}$	$6.4x10^{-1}$	$6.4x10^{-1}$
16	$4.0x10^{-3}$	$4.0x10^{-1}$	$1.1x10^{0}$	$1.1x10^{0}$	$1.1x10^{0}$
32	$1.2x10^{-2}$	$8.2x10^{-1}$	$1.8x10^{0}$	$1.8x10^{0}$	$1.8x10^{0}$
64	$3.2x10^{-2}$	$1.7x10^{0}$	$2.9x10^{0}$	$2.9x10^{0}$	$2.9x10^{0}$

Table XXVI. Absorption Coefficient for Rain as a Function of Rain Rate for Frequencies of 9.375, 35, 94, 140 and 240 GHz (data from Ref. 53)

RAINFALL RATE (MM/HR)	RAIN ABSORPTION COEFFICIENT (KM^{-1})				
	FREQUENCY (GHz)				
	9.375	35	94	140	240
1	$2.0x10^{-3}$	$4.5x10^{-2}$	$1.2x10^{-1}$	$1.4x10^{-1}$	$1.4x10^{-1}$
2	$4.8x10^{-3}$	$8.7x10^{-2}$	$2.0x10^{-1}$	$2.3x10^{-1}$	$2.3x10^{-1}$
4	$1.2x10^{-2}$	$1.6x10^{-1}$	$3.3x10^{-1}$	$3.7x10^{-1}$	$3.7x10^{-1}$
8	$2.9x10^{-2}$	$3.0x10^{-1}$	$5.4x10^{-1}$	$6.2x10^{-1}$	$6.2x10^{-1}$
16	$6.5x10^{-2}$	$5.6x10^{-1}$	$8.7x10^{-1}$	$1.0x10^{0}$	$1.0x10^{0}$
32	$1.6x10^{-1}$	$1.0x10^{0}$	$1.5x10^{0}$	$1.7x10^{0}$	$1.7x10^{0}$
64	$3.8x10^{-1}$	$1.8x10^{0}$	$2.3x10^{0}$	$2.6x10^{0}$	$2.6x10^{0}$

D. C. Hogg's[54] measured data on the one-way attenuation due to rain at 70 GHz and some theoretical data by Crane,[26] and SRI[40] are presented in Fig. 25. Crane[26] calculated the one-way attenuation in rain vs rainfall rate and showed that the Laws and Parson's model fits Hogg's data best; Crane's data are for frequencies of 15.5, 35, 70, and 94 GHz. V. Richard[40] compiled this set of Crane's data, and his compilation is shown in Fig. 26.

D. Deirmendjian's[22] calculations of the extinction coefficient resulting from rainfall are given in Fig. 20, where the extinction coefficient β_{ext}, km^{-1} vs wavelength is shown for 3 cloud models and 2 rainfall models. The wavelength coverage is from 1.0 μm to 100 mm.

Downs[44] has combined the scattering and absorption tables for visible, IR, microwave and millimeter wave radiation, and his results, giving the rainfall attenuation coefficients vs rainfall rate, are presented in Table XXVII.

Wilcox and Graziano[27] calculated the combined atmospheric attenuation by water vapor (α_w(vapor)), oxygen (α_o), and rain (α_w(cond)). They plotted the total attenuation (db/km) vs rainfall rate for radiation of wavelength 3, 4, 8, and 10 mm, for rainfall rates of 0.1 mm/hr to 100 mm per hour. Their results are presented in Fig. 27.

Crane[26] has calculated the rain backscatter cross section per unit volume of rain at 0°C vs rainfall rate for 15.5, 35, 70, and 94 GHz, using the Mie scattering theory. His data are presented in Fig. 28. (Downs[40] collected Crane's curves and produced the composite curve presented here as Fig. 28.) Victor Richard and John Kammerer[55] of BRL have collected data from measurements and calculations of the radar backscatter cross section per unit volume for 9.375, 35, 70 and 95 GHz frequencies. These data are plotted as a function of rain rate, from 0.1 mm/hr to 100 mm/hr in Figs. 29, 30, 31, and 32. Figure 29 presents BRL's measured data of backscatter cross section vs rain rate for the 4 frequencies mentioned. Figure 30 presents BRL's 35 GHz backscatter cross section vs rain rate as well as a number of other calculations and measurements. Figure 31 presents BRL's 70 GHz data and a collection of other calculations and

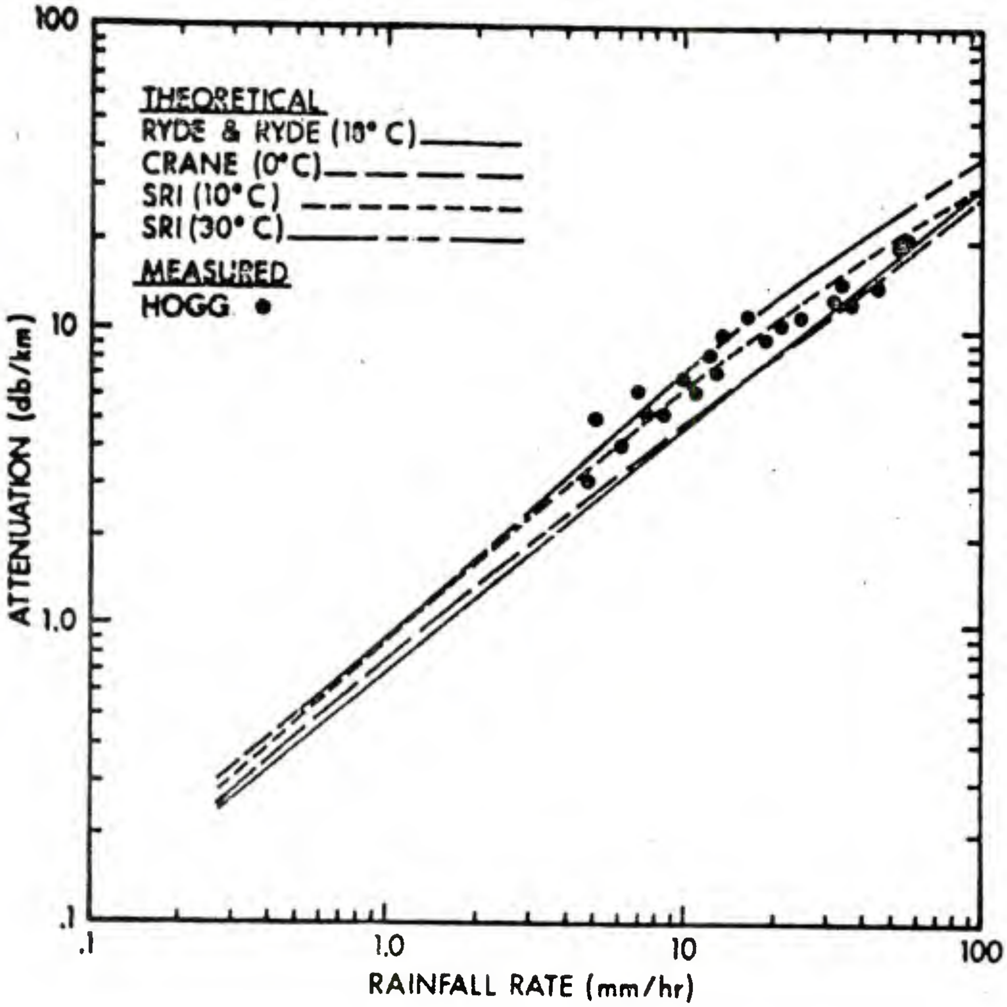


Fig. 25. Comparison of Theoretical and Measured Data on One-Way Attenuation in Rain at 70 GHz (data from Refs. 26, 40 and 54)

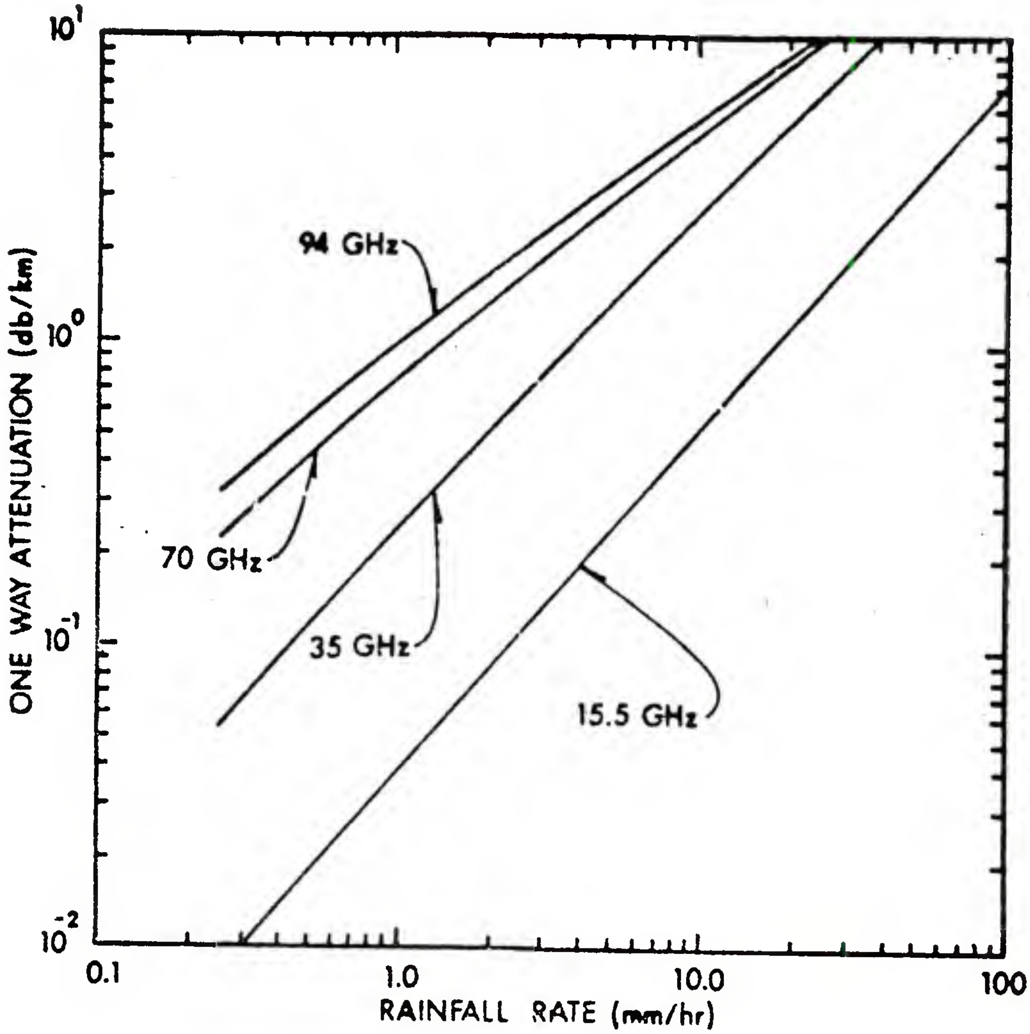


Fig. 26. One-Way Attenuation in Rain vs Rainfall Rate for Frequencies of 15.5, 35, 70 and 94 GHz (Data from Refs. 26 and 40)

Table XXVII. Attenuation Coefficient for Rain as a Function of Rainfall Rate (Data from Ref. 44)

RAINFALL RATE (MM/HR)	RAIN ATTENUATION COEFFICIENT (KM^{-1})									
	WAVELENGTH (MICRONS)					FREQUENCY (GHZ)				
	0.55	1.06	2.3	3.8	10.6	9.375	36	94	140	240
1	2.4×10^{-1}	2.5×10^{-1}	3.0×10^{-1}	3.1×10^{-1}	3.2×10^{-1}	2.1×10^{-3}	6.3×10^{-2}	2.6×10^{-1}	3.0×10^{-1}	3.0×10^{-1}
2	3.8×10^{-1}	3.9×10^{-1}	4.6×10^{-1}	4.7×10^{-1}	4.8×10^{-1}	5.0×10^{-3}	1.3×10^{-1}	4.6×10^{-1}	4.7×10^{-1}	4.7×10^{-1}
4	5.8×10^{-1}	6.0×10^{-1}	7.0×10^{-1}	7.2×10^{-1}	7.4×10^{-1}	1.2×10^{-2}	2.4×10^{-1}	7.0×10^{-1}	7.5×10^{-1}	7.5×10^{-1}
8	8.8×10^{-1}	9.2×10^{-1}	1.1×10^{0}	1.1×10^{0}	1.1×10^{0}	3.0×10^{-2}	4.8×10^{-1}	1.2×10^{0}	1.3×10^{0}	1.3×10^{0}
16	1.4×10^{0}	1.4×10^{0}	1.7×10^{0}	1.7×10^{0}	1.7×10^{0}	6.9×10^{-2}	9.6×10^{-1}	2.0×10^{0}	2.1×10^{0}	2.1×10^{0}
32	2.1×10^{0}	2.2×10^{0}	2.6×10^{0}	2.6×10^{0}	2.7×10^{0}	1.7×10^{-2}	1.8×10^{0}	3.3×10^{0}	3.5×10^{0}	3.5×10^{0}
64	3.2×10^{0}	3.4×10^{0}	4.0×10^{0}	4.0×10^{0}	4.1×10^{0}	4.1×10^{-1}	3.5×10^{0}	5.2×10^{0}	5.5×10^{0}	5.5×10^{0}

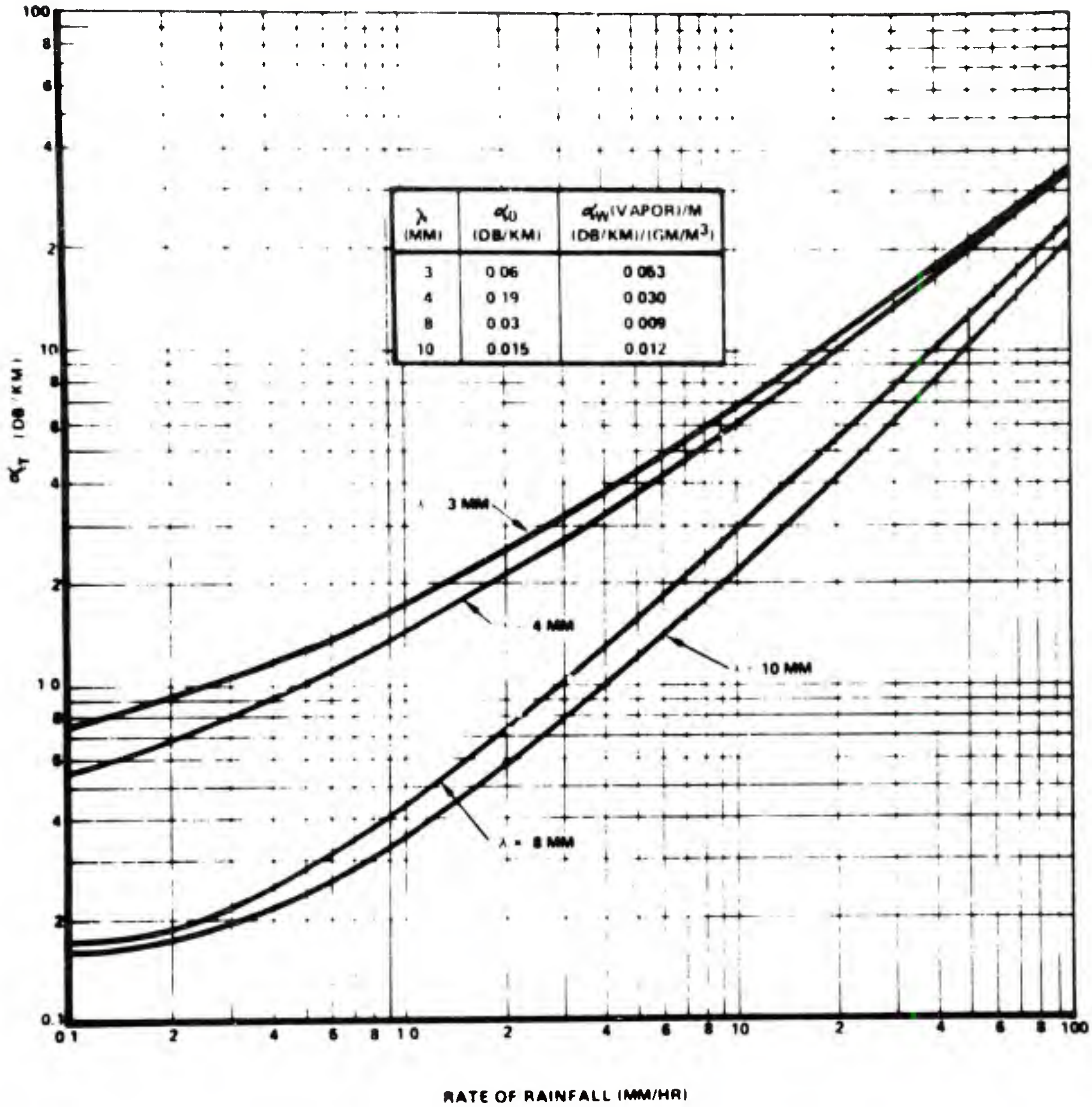


Fig. 27. Combined Atmospheric Attenuation Caused by Water Vapor (α_w (Vapor)), Oxygen (α_o), and Rain (α_w (Cond)) as a Function of the Rate of Rainfall for Wavelengths of 3, 4, 8 and 10 mm (Data from Ref. 27)

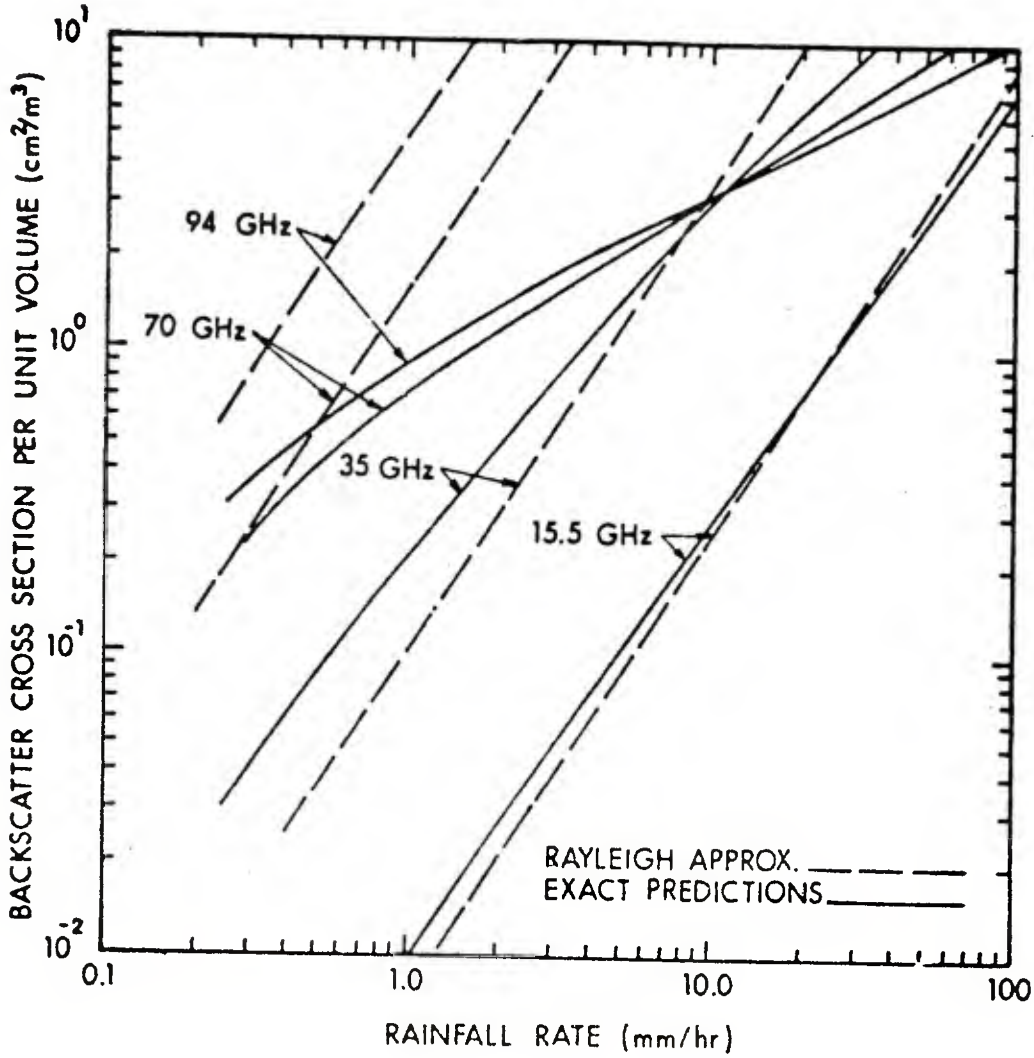
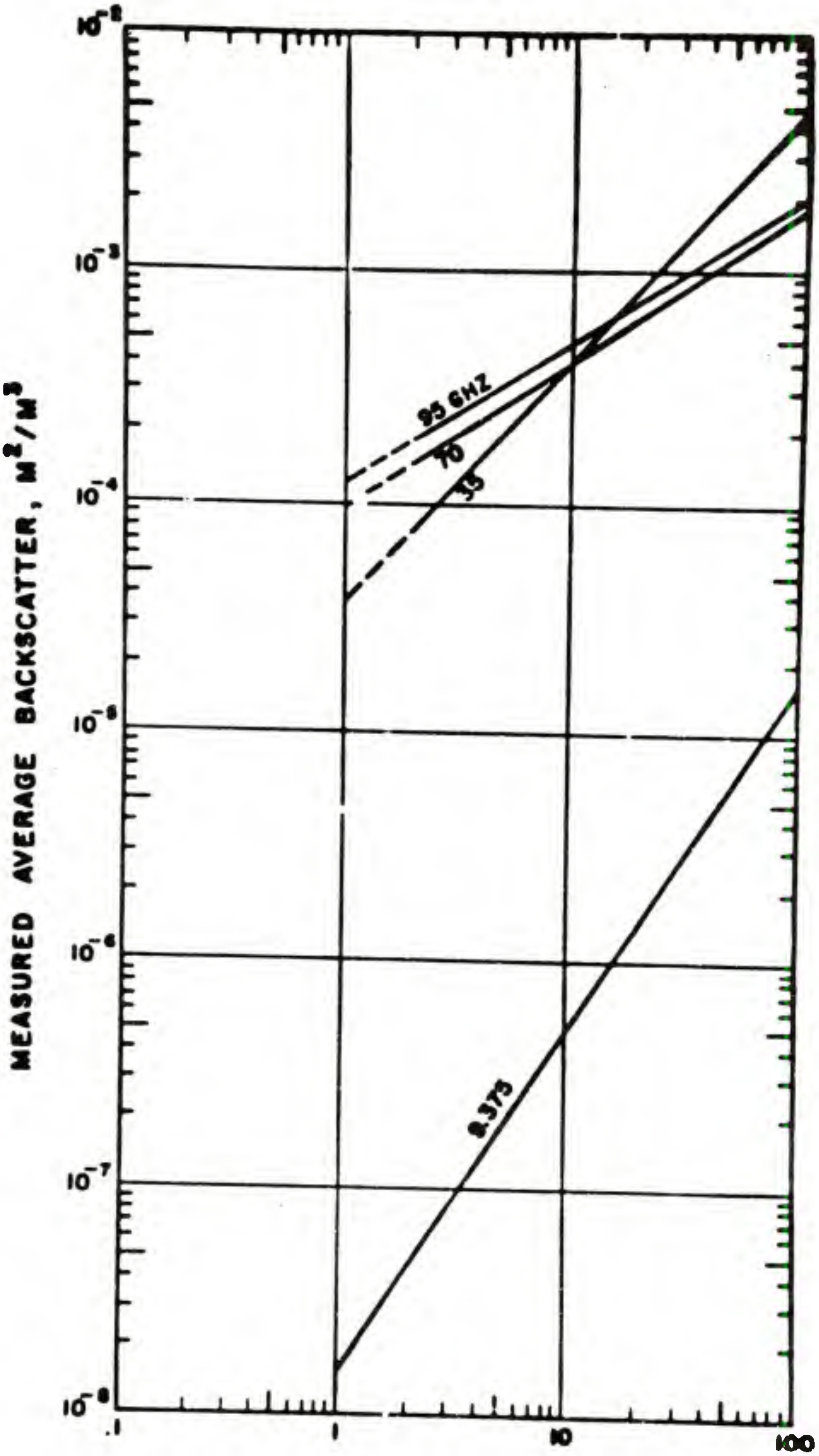


Fig. 28. Backscatter Cross Section per Unit Volume of Rain at 0°C versus Rainfall Rate for 15.5, 35, 70 and 94 GHz Radiation (Data from Refs. 26 and 40)



RAIN RATE (mm/hr)

Fig. 29. Measured Backscatter Cross Section for Rain vs Rain Rate for Frequencies of 9.375, 35, 70 and 95 GHz (Data from Ref. 55)

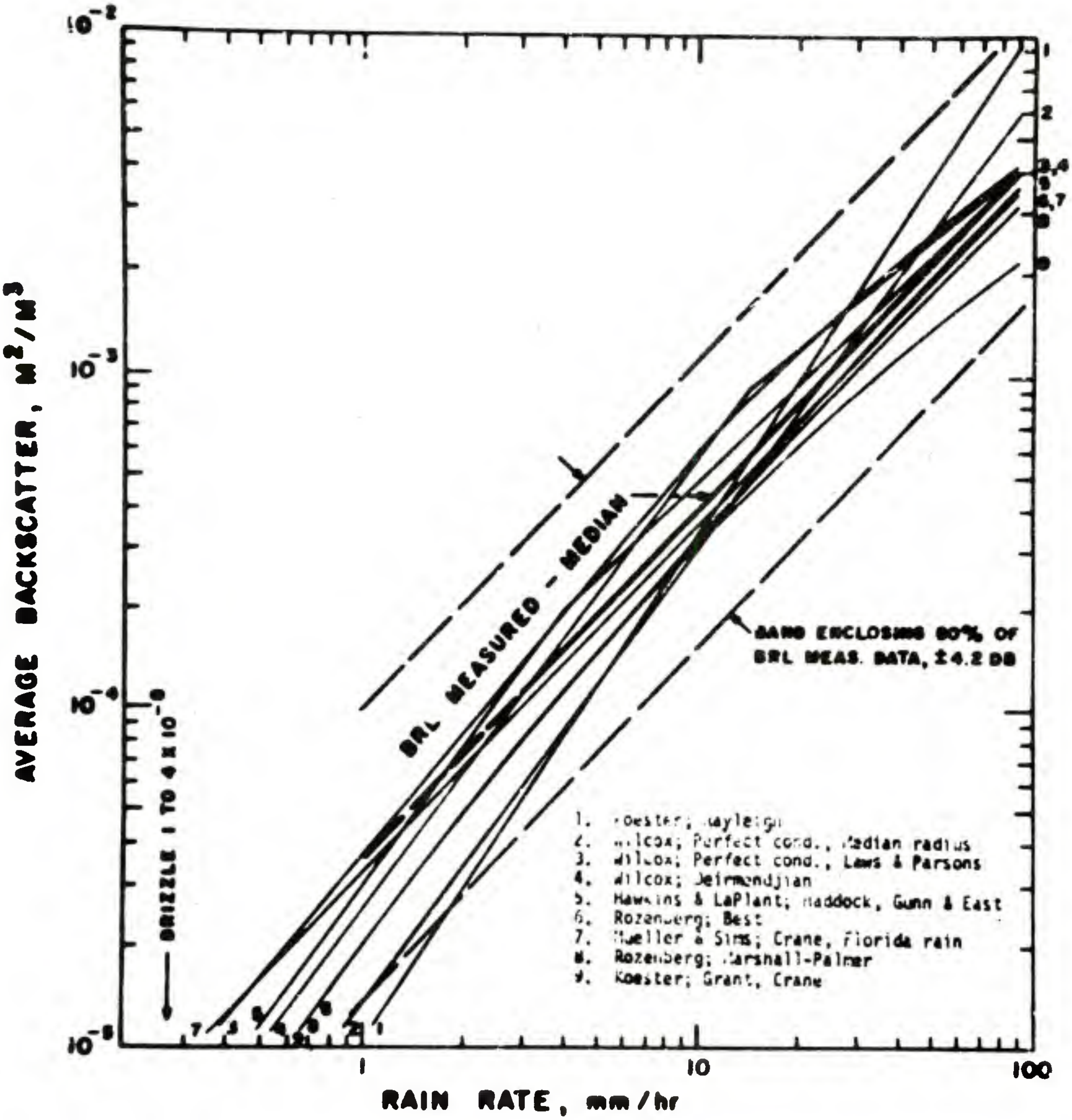


Fig. 30. Measured and Calculated Backscatter Cross Section for 35 GHz Radiation in Rain as a Function of Rain Rate (Data from Ref. 55)

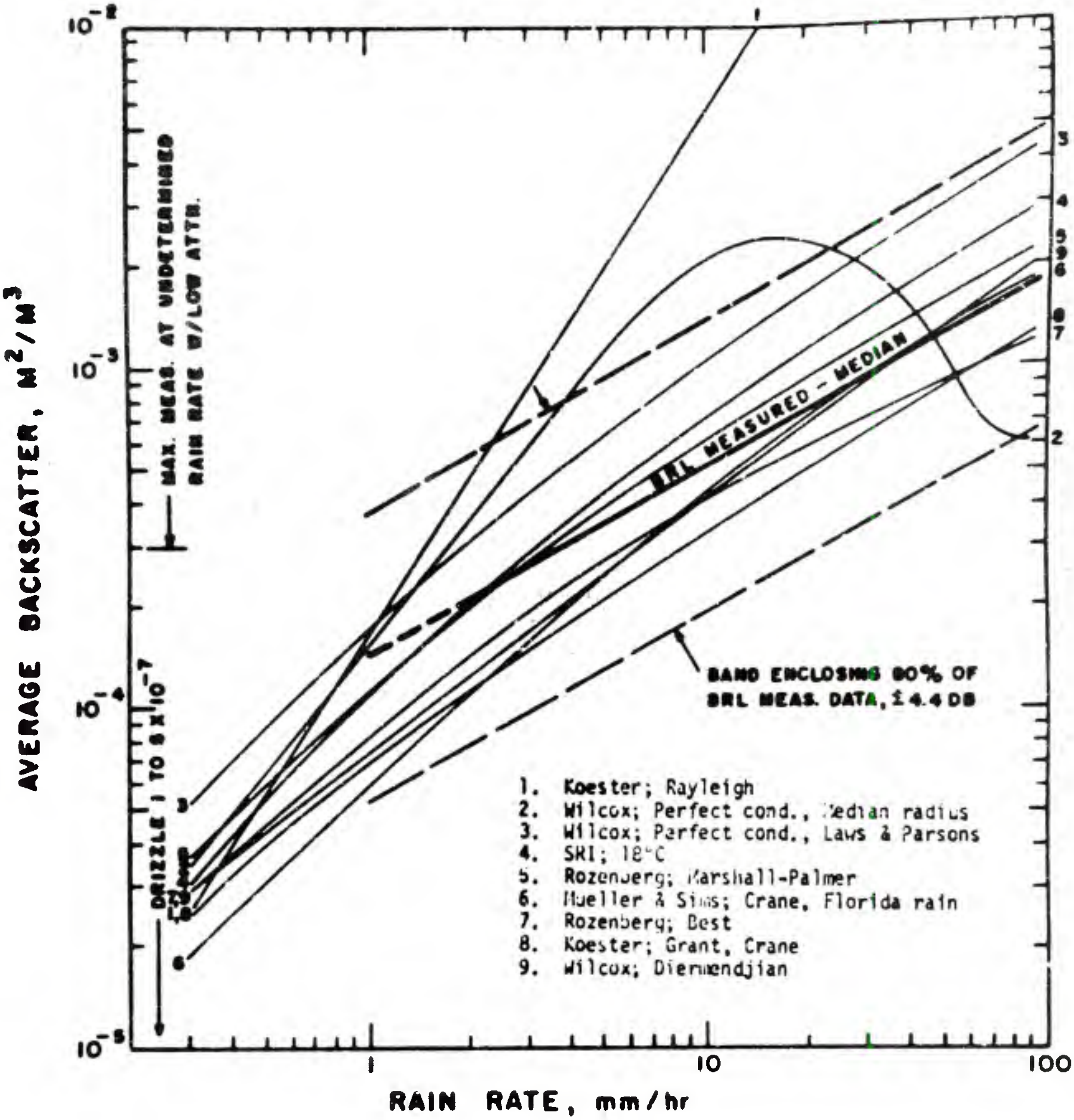


Fig. 31. Measured and Calculated Backscatter Cross Section for 70 GHz Radiation in Rain as a Function of Rain Rate (Data from Ref. 55)

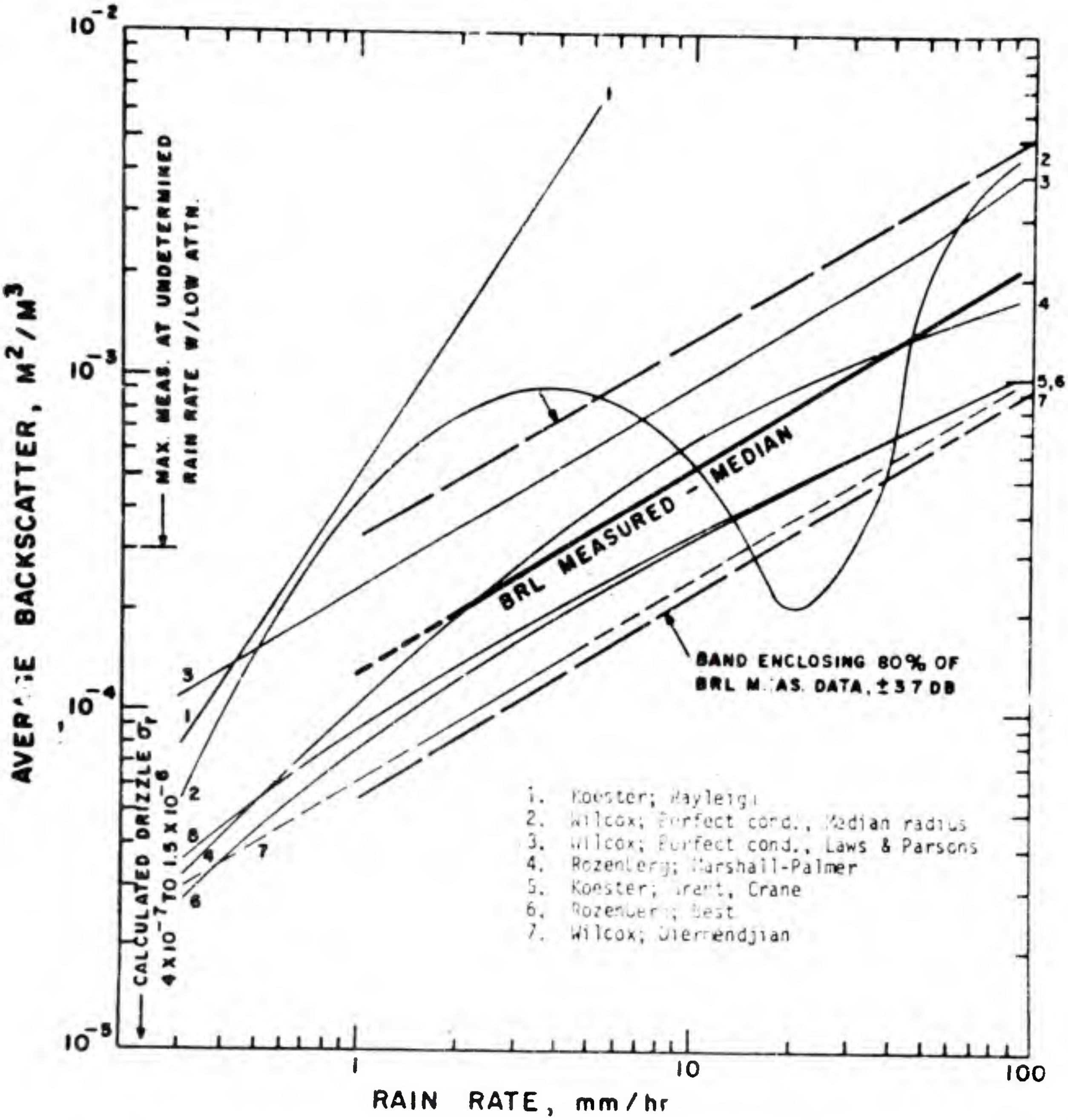


Fig. 32. Measured and Calculated Rain Backscatter Cross Section for 95 GHz Radiation in Rain as a Function of Rain Rate (Data from Ref. 55)

measurements which were referred to in their article. Figure 32 presents BRL's 95 GHz data along with other calculations and measurements. The reader is referred to Ref. 55 for further details on these curves.

A. V. Sokolov[56] computed the attenuation in rain, in dB/km vs intensity of rainfall, 1-100 mm/hr, for visible, IR, and microwave frequencies, for .63 μm - 8 mm, using Mie theory, where applicable, and Best's drop-size distribution. His results are shown in Table XXVIII.

Serge Godard[57] measured the reflectivity of rain drops as a function of drop radius for radiation of .86 cm, 3.21 cm, 5.5 cm, and 10 cm wavelength. His data on rain-drop reflections are shown here in Fig. 33. He also found that for 0.86 cm waves, the attenuation in rain is really independent of the drop-size distribution; even though the reflectivity is very much a function of drop diameter.

Malinkin, Sokolov, and Sukkonen[58] measured the attenuation coefficient in dB/km for 8.6 mm radiation, and computed the attenuation for 1, 2, 4 and 8.6 mm radiation. The results of their calculations are shown in Fig. 34. Figure 35 shows more details of their measured and calculational data on the attenuation coefficient at λ=8.6 mm as a function of rainfall rate.

Sokolov and Sukkonen[59] computed the attenuation of radio-waves in the 0.1-2mm range using the drop-size distributions of both Best and Polyakova. For rain rate less than 10-12 mm/hr, using Mie theory, the computations were in agreement with experimental data at 0.96 mm. The results of their theoretical calculations are shown in Table XXIX.

Bakin, Zimin et al.[60] measured the attenuation in rain of radio-waves of 0.96 mm. The results of their measurements are shown in Fig. 36. They found that compared to radiation of 8.6 mm, the attenuation at 0.96 mm is larger roughly by a factor of 2.5 to 3.0. Table XXX tabulates their data (average values) with some of Medhurst[61] at 0.96, 4.3, 6.2, 8.6 and 9.6 mm for rainfall intensity of 5 and 12 mm/hr.

In 1970, V. I. Rozenberg[62] performed a critical review of radar characteristics of rain in the submillimeter range. He calculated the backscattering cross section and the attenuation coefficient for sub-millimeter radiation using the Marshall-Palmer and Best drop-size

Table XXVIII. Attenuation Coefficient for Rain vs Rainfall Intensity for Wavelengths between 0.63 µm and 8 mm (Data from Ref. 56)

Attenuation Coefficient τ(dB/km)

Intensity of rain, mm/hr	Wavelength of radiation									
	0.63 µm	3.5 µm	10.6 µm	100 µm	300 µm	800 µm	1 mm	2 mm	4 mm	8 mm
1	1.1	1.1	1.1	1.5	1.5	1.6	1.7	1.5	0.8	0.3
5	3.0	3.0	3.0	3.4	3.5	3.6	3.7	3.6	2.9	1.4
10	4.5	4.5	4.5	5.2	5.4	5.6	5.7	5.6	4.8	2.7
25	7.8	7.9	7.9	8.8	9.3	9.6	9.4	9.3	8.9	5.9
50	12.5	12.6	12.6	13.9	14.7	15.3	15.6	16.0	15.0	11.1
100	18.2	18.5	18.5	20.0	21.3	22.1	22.7	23.0	22.3	17.3

Table XXIX. Calculated Attenuation Coefficient for Rain vs Rainfall Rate for Drop-Size Distributions of Best and Polyakova at T=20°C

Attenuation Coefficient γ(dB/km)

I, mm/hr	Wavelength λ, mm									
	2.0		1.0		0.8		0.5		0.1	
	B[a]	P[b]	B	P	B	P	B	P	B	P
0.5	0.7	0.8	0.9	0.8	0.9	0.8	0.9	0.8	0.8	0.6
1.0	1.5	1.3	1.7	1.3	1.6	1.2	1.6	1.1	1.5	1.0
2.5	2.3	2.6	2.4	2.5	2.4	2.4	2.3	2.2	2.1	2.0
5.0	3.6	4.1	3.7	3.9	3.6	3.8	3.5	3.4	3.2	3.1
10.0	5.6	7.7	5.7	7.2	5.6	7.0	5.4	6.3	4.9	5.8
25.0	9.3	13.8	9.9	12.8	9.6	12.5	9.3	11.2	8.3	10.4
50.0	16.0	22.1	15.6	20.5	15.3	20.0	14.7	18.1	12.7	16.6
100.0	23.0	34.0	22.7	31.5	22.1	30.0	21.3	28.4	18.0	26.5

a. Calculated using the Best Distribution
b. Calculated using the Polyakova Distribution

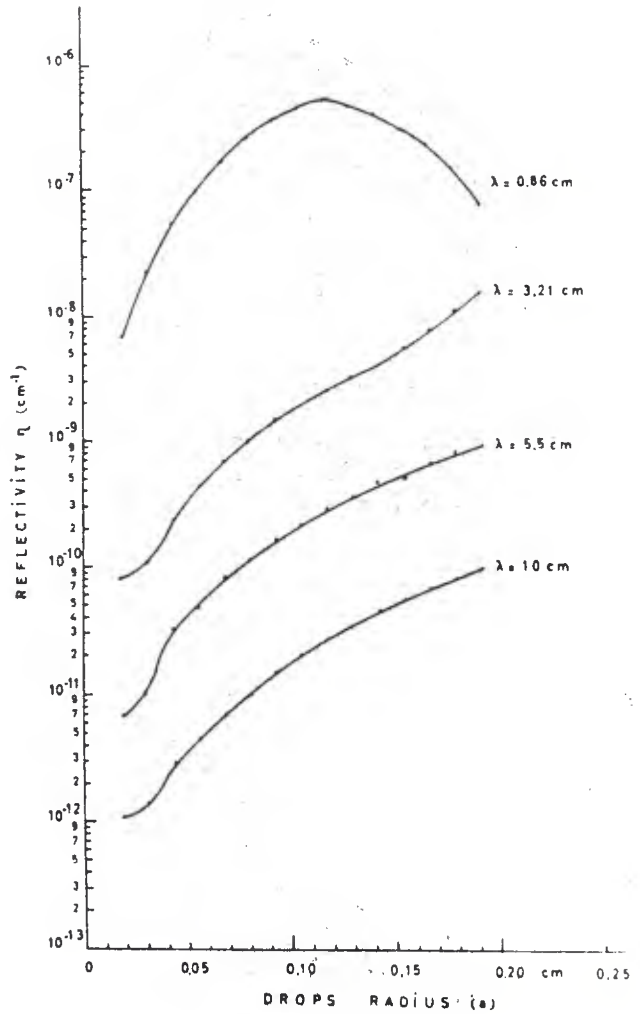


Fig. 33. Rain Drop Reflection as a Function of Drop Size for Several Wavelengths (Data from Ref. 57)

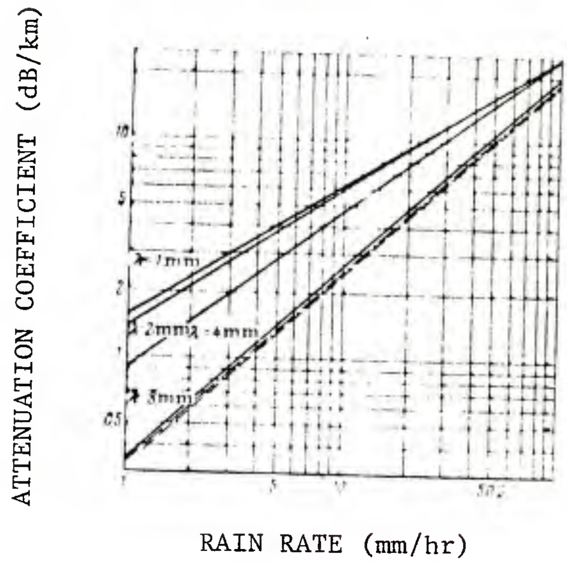


Fig. 34. Computed Attenuation Coefficients at λ=1, 2, 4 and 8.6 mm vs Rainfall Rate (Data from Ref. 58)

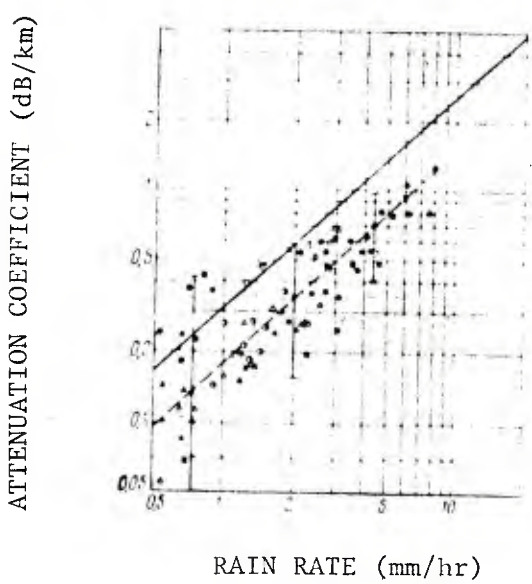


Fig. 35. Measured and Calculated Attenuation Coefficients at λ=8.6 mm vs Rainfall Rate: Solid Curve is Calculated Data, Dashed Curve is Average of Measured Data, Points are Measured Data (Data from Ref. 58)

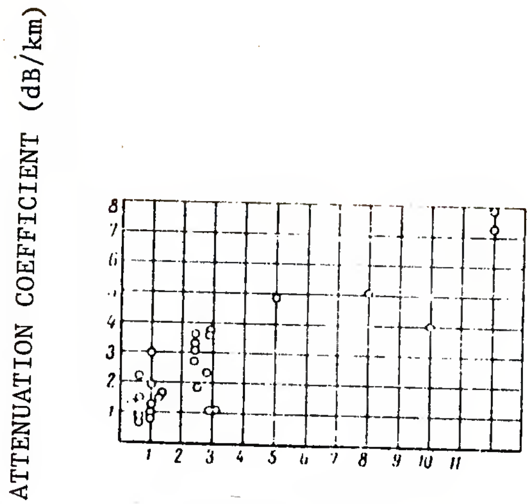


Fig. 36. Measured Attenuation in Rain for 0.96 cm Radiation vs Rainfall Rate (Data from Ref. 60)

Table XXX. Average Values of the Attenuation Coefficient in Rain for Rainfall Intensities of 5 and 12 mm/hr and Wavelengths of 0.96, 4.3, 6.2, 8.6 and 9.6 mm (Data from Ref. 63)

Attenuation Coefficient (dB/km)

Wave-length (mm)	Intensity (mm/hr)	
	5	12
0.96	4.8	7.8
4.3	3.5	6.0
6.2	3.0	6.5
8.6	2.2	3.0
9.6	1.2	2.0

distributions. Results of his calculations for the backscattering cross section in units of (m^{-1}) are shown in Fig. 37. His attenuation coefficient, in dB/km, is shown in Fig. 38. Both calculations were for radiation of wavelengths of 0.3 mm to 10 cm, and rainfall rates of 0.1, 1, 10, and 100 mm/hr. He presented a large bibliography on work performed prior to 1970, with 60 references.

Joerg Sander[63] measured the attenuation due to rain at 5.77, 3.3, and 2 mm. Simultaneously recorded were rainfall rate and a part of the drop-size spectrum. He calculated the total cross section of spherical water drops at a temperature of 10°C as a function of radius, from 0.3-3.5 mm, using Mie scattering theory. Sander's calculated cross section data are shown in Fig. 39. His measured attenuation data are presented in Figs. 40, 41, and 42 as scattergrams for 5.77, 3.3 and 2.0 mm wavelength radiation respectively. The measured data are compared in these figures with a calculation of the attenuation in dB/km vs rainfall rate for 5.77 mm, 3.3 mm and 2 mm radiation, respectively. Also plotted on these scattergrams were regression curves for rainfall rate with attenuation, $\overline{R}_A|D$, and attenuation with rainfall rate $\overline{D}|R_A$.

Robert Crane wrote a tutorial article on "Attenuation due to Rain, a Mini Review."[64] He reviewed progress on the development and verification of a theory of rain-caused attenuation, and considers the the statistical models required to predict attenuation, ca 1975. Wavelength coverage in his article appears to be from 15 cm to 0.8 cm.

R. R. Rogers[65] has reviewed "Statistical Rainstorms Models: Their Theoretical and Physical Foundations," in a long article, ca 1976. Most of the data discussed by Rogers is for propagation of 10-20 GHz radiation in rain, but some millimeter wavelength data is discussed. He has a number of suggestions for further research.

G. C. McCormick[66] wrote an article on theory of propagation in a precipitation medium, considering the polarization aspects of the rain. He concluded that the most advantageous polarizations for the measurements for (rain) medium characteristics are right-hand circular, left-hand circular, and ± 45° slant linear (with respect to the rainfall direction).

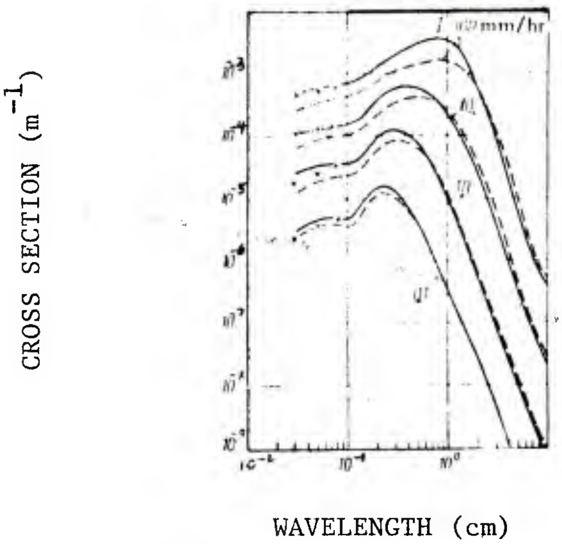


Fig. 37. Specific Backscattering Cross Section of Rain of Different Intensity at 18°C, Marshall-Palmer Distribution (dashed lines) (Data from Ref. 62)

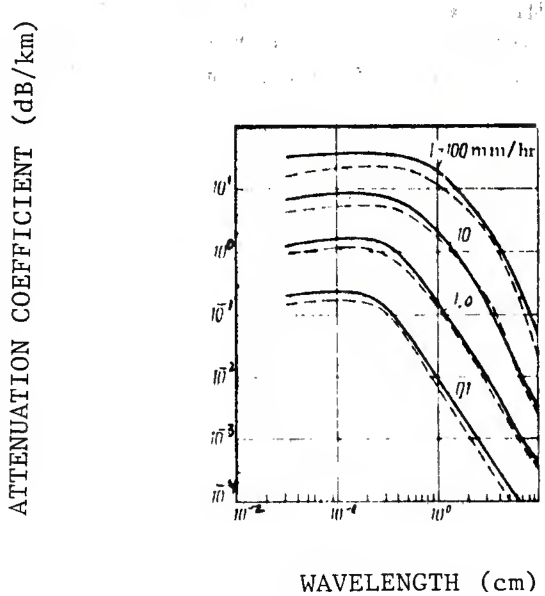


Fig. 38. Attenuation Coefficient of Rain of Different Intensity at 18°C, Marshall-Palmer Distribution (continuous lines) and Best Distribution (dashed lines) (Data from Ref. 62)

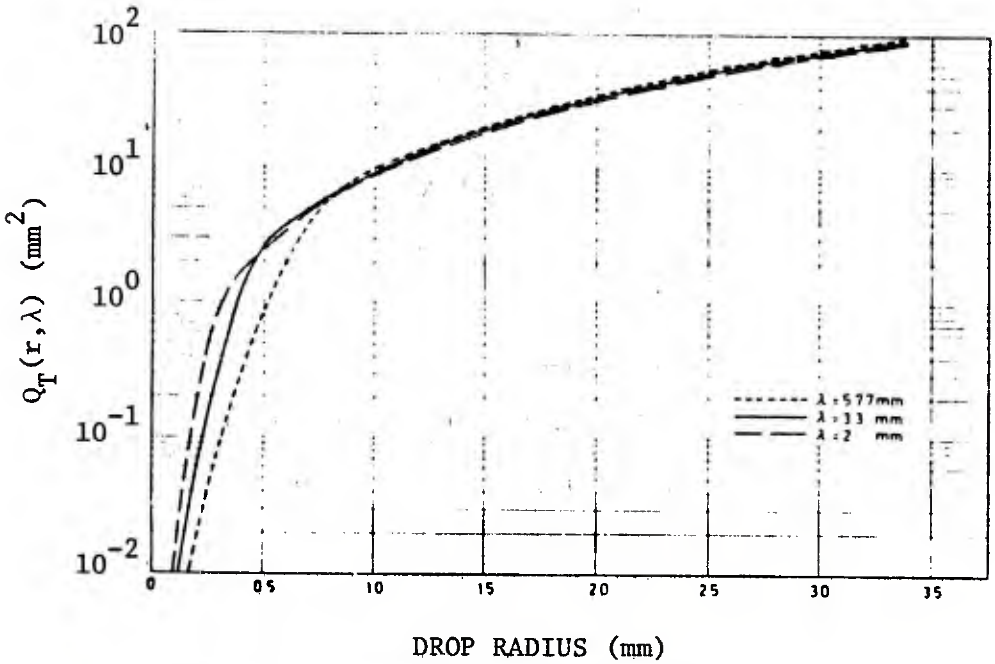


Fig. 39. Mie Calculations of the Extinction Efficiency for Rain Drops vs Drop Radius for λ=5.77, 3.3 and 2.0 mm (Data from Ref. 63)

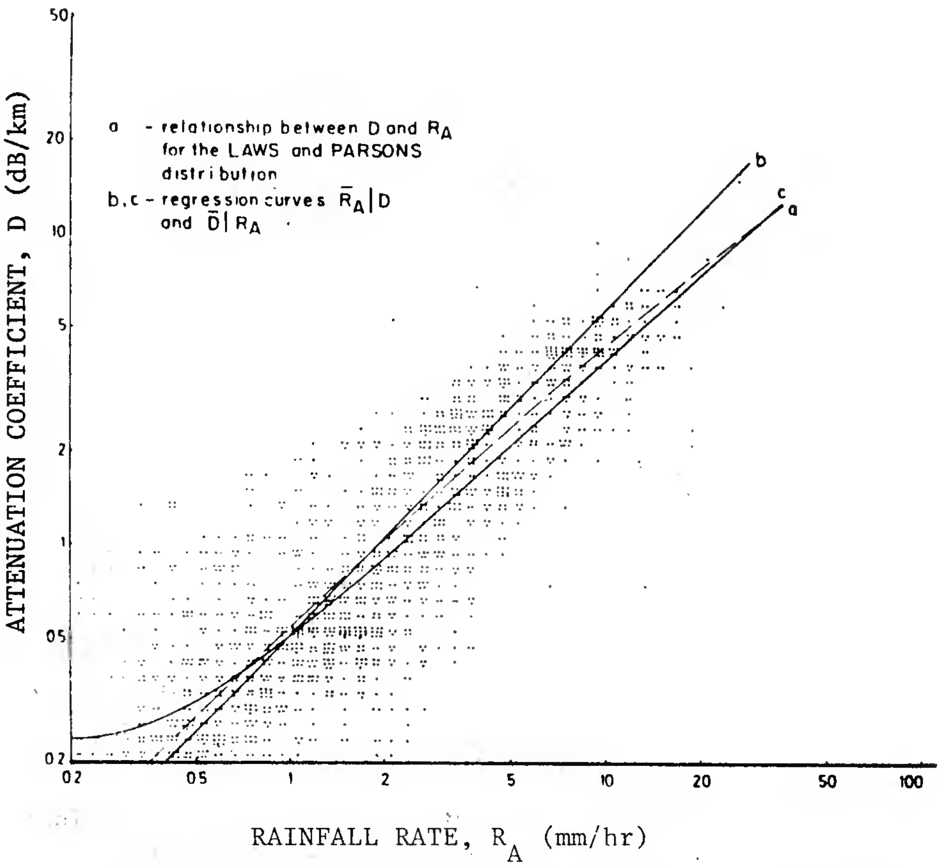


Fig. 40. Measured Attenuation Coefficients vs Rainfall Rate, R_A, at λ=5.77 μm (Data form Ref. 63)

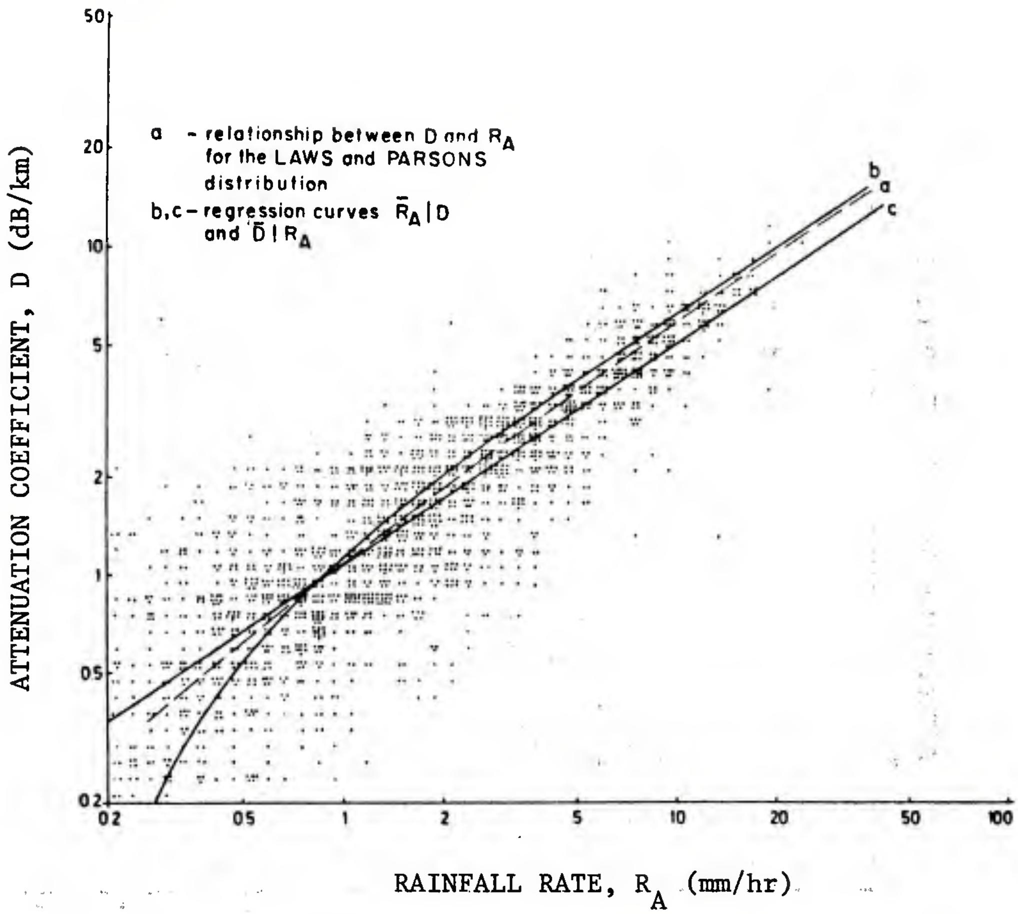


Fig. 41. Measured Attenuation Coefficients vs Rainfall Rate, R_A, at λ=3.3 mm (Data from Ref. 63)

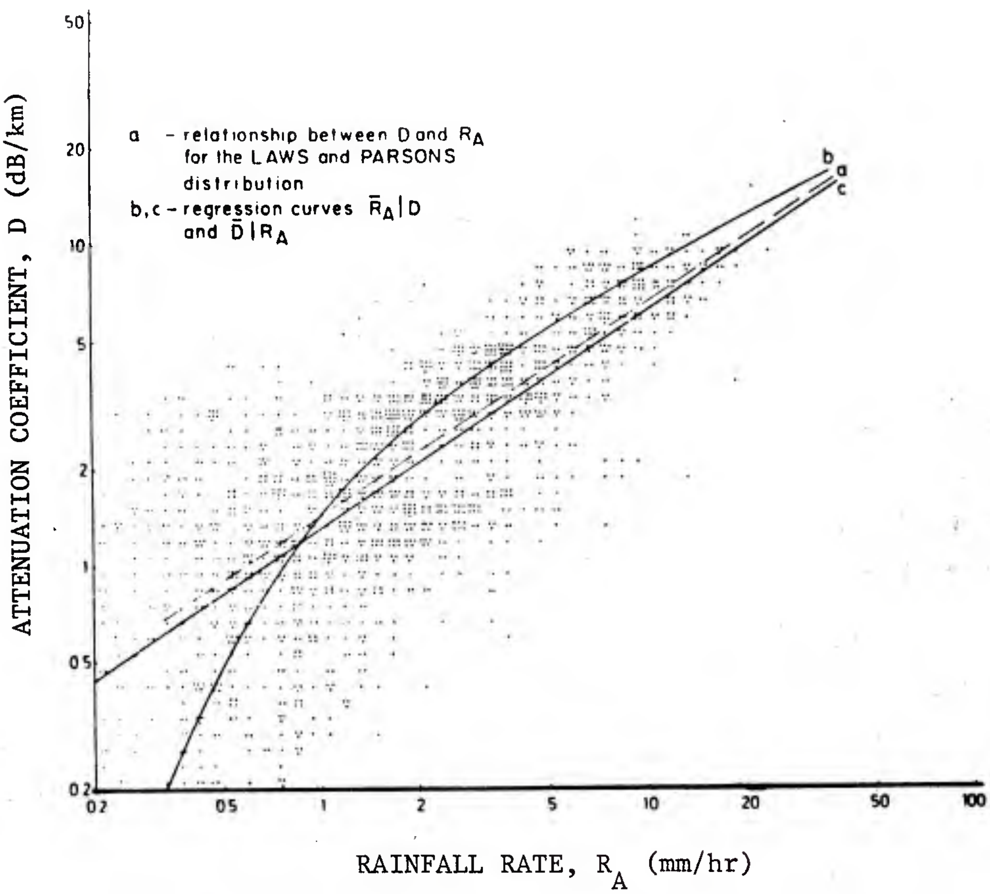


Fig. 42. Measured Attenuation Coefficients vs Rainfall Rate, R_A, at λ=2 mm (Data from Ref. 63)

Radio waves of 16.5 - 30.9 GHz were considered in his calculations.

Julian Goldhirsh[67] computed some attenuation fade statistics for satellite to 2 ground stations separated by a distance d. He modeled the total (zenith path) attenuation by

$$A_i = \int_0^{\ell i} k(\ell)d\ell \text{ (in dB)},$$

where $$k(\ell) \simeq a[z(\ell)]^b \text{ in dB/km..}$$

The values of a and b used by Goldhirsh are given in Table XXXI. He also computed the joint conditional probability that attenuation at two terminals separated by a distance d exceeds the abcissa at path elevation angle $\theta = 45°$ at 100 GHz. His joint probability calculations are presented here as Fig. 43. He has done similar calculations for frequencies of 13, 18, and 30 GHz. He used the radar reflectivity of rain at 2.8 GHz as part of his data base.

P. Wiley[68] in his PhD thesis, considered the non-sphericity of raindrops regarding scattering calculations, reviewing Oguchi's work of the 1960s. He then extensively reviewed the literature on cm and mm rainfall propagation experiments. He analyzed in detail some 19.3 GHz data for polarization effects. He compared his results for rainfall attenuation with that of Oguchi, for horizontal and vertical polarization for a 1.43 km path at 19.3 GHz. His data are shown here as Fig. 44. He calculated the cross polarization vs pathlength for a tilt angle of 60° and a frequency of 19.36 GHz. His results are shown in Fig. 45. He did similar calculations for a tilt angle of 75°; those results are shown in Fig. 46. Conclusions he reached regarding the influence of polarization on millimeter wave propagation through rain are the following:

1) The best polarizations to use for a depolarization experiment are ± 45° from the vertical. 2) Vertical and horizontal polarizations should not be used for a depolarization experiment. 3) Vertical polarization suffers the least average attenuation during rainfall. 4) Oguchi's attenuation and phase rotations for 19.36 GHz are correct. 5) The effective

Table XXXI. Best Fit Values of a and b for $k = aZ^b$ (k in dB/km, Z in mm^6/m^3)

(Data from Ref. 67)

f (GHz)	a	b
13	3.15×10^{-4}	0.732
18	9.12×10^{-4}	0.681
25	3.25×10^{-3}	0.610
30	6.82×10^{-3}	0.570
100	6.20×10^{-2}	0.429

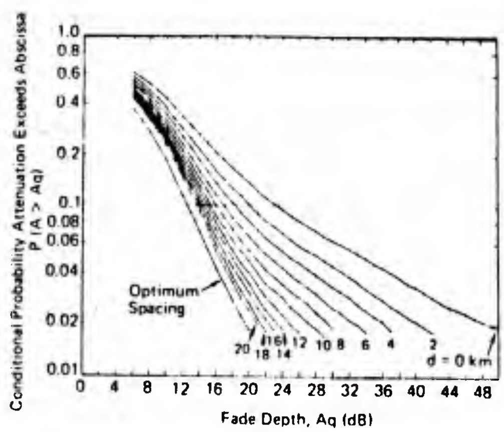


Fig. 43. Joint Conditional Probability that Attenuation at Two Terminals Separated by Distance d Exceeds the Abscissa at Path Elevation Angle θ=45° at f=100 GHz (Data from Ref. 67)

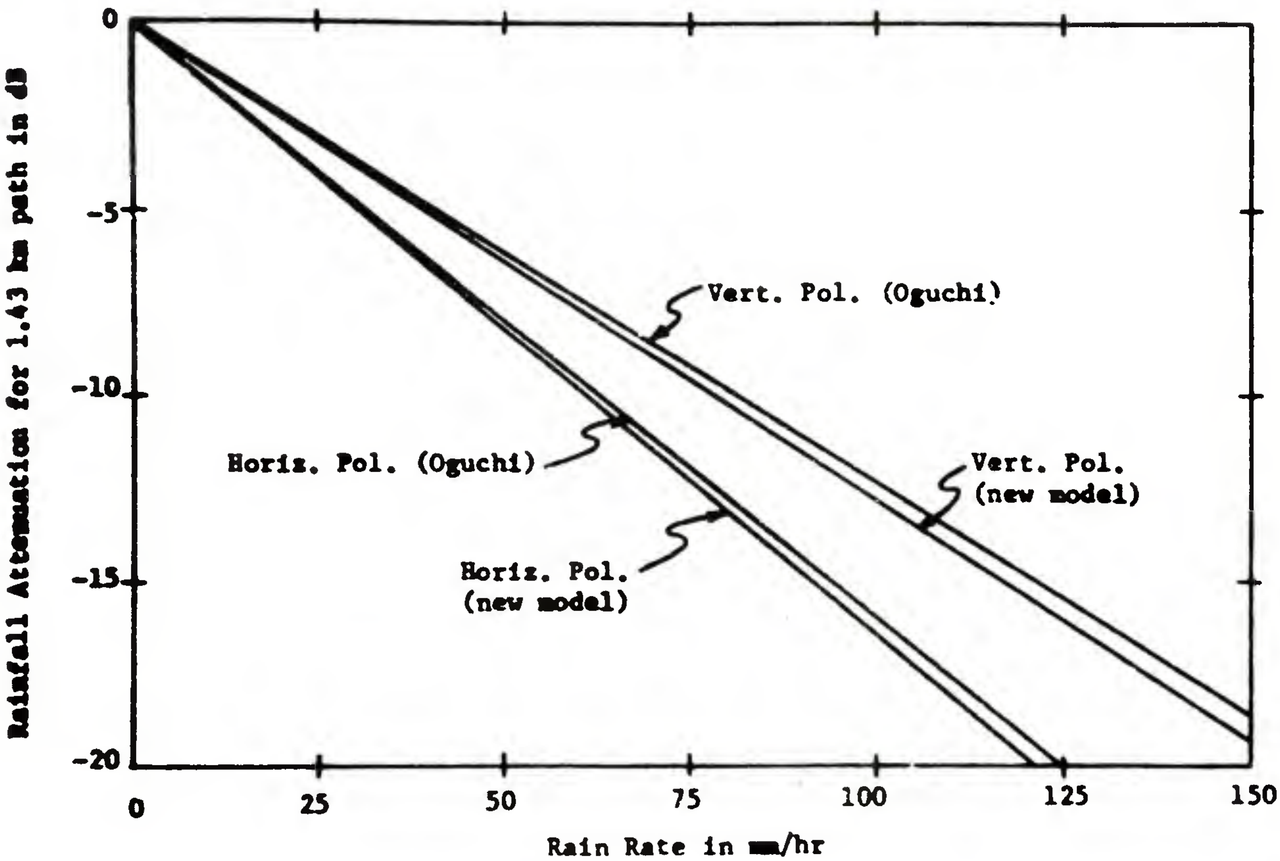


Fig. 44. Theoretical Prediction of Rainfall Attenuation at 19.3 GHz for a 1.43 km Path (Data from Ref. 68)

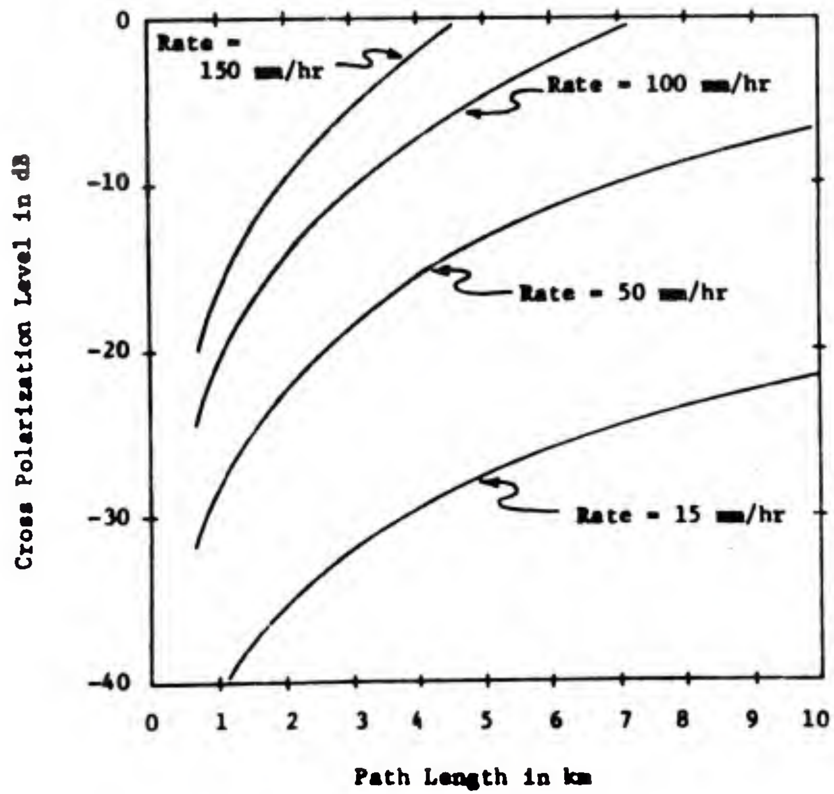


Fig. 45. Cross Polarization vs Path Length in Rain for a Tilt Angle of 60° and a Frequency of 19.3 GHz (Data from Ref. 68)

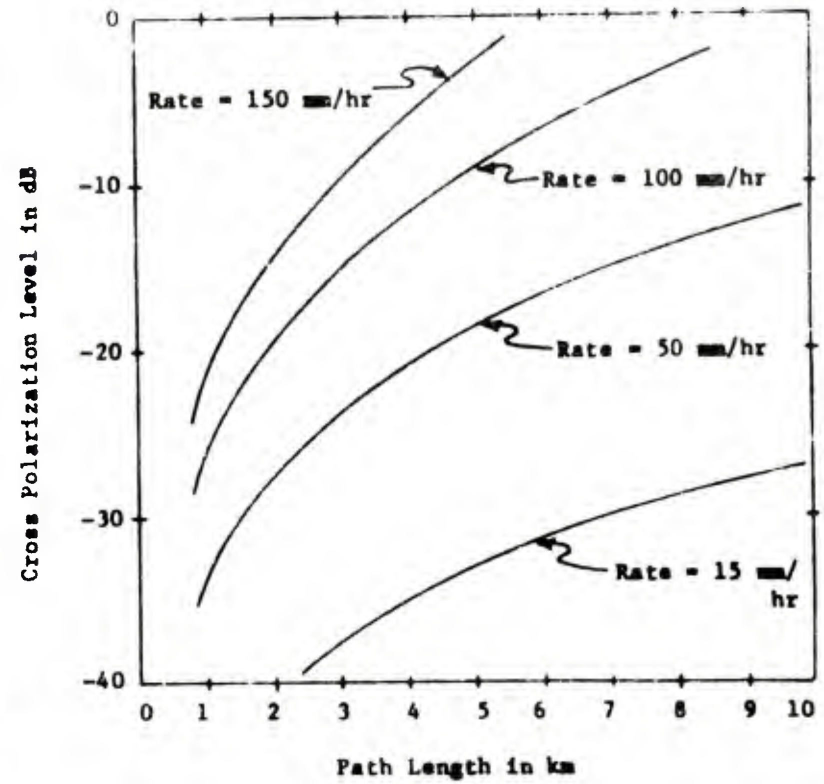


Fig. 46. Cross Polarization vs Path Length in Rain for a Tilt Angle of 75° and a Frequency of 19.3 GHz (Data from Ref. 68)

percentage of oblate drops assumed in an analysis is critical to the predicted polarization level. 6) Polarization diversity is not feasible as a means of increasing resistance to rain-induced fading. 7) The use of polarization multiplexing utilizing orthagonal polarizations is limited to very short path lengths. 8) Use of a distribution of raindrop sizes is unnecessary to get good agreement between theory and experiment(!).

Louis Ippolito,[69] the NASA Goddard ATS-5 and 6 millimeter wave communications experiment manager, wrote his 1977 PhD thesis on "Scattering in Discrete Random Media with Implications to Propagation through Rain." Ippolito[70] investigated the multiple scattering effects on wave propagation through a volume of discrete scatterers. The mean field and intensity for a distribution of scatterers was developed using a discrete random media formulation, and second order series expansions for the mean field and total intensity derived for one-dimensional and three-dimensional configurations. The volume distribution results were shown to proceed directly from the one-dimensional results. Ippolito's analyses demonstrated that either discrete or continuous techniques may be employed for the mean field and intensity expansions, as long as care is taken to insure non-overlapping scatterers in the formulation. The multiple scattering intensity expansion was compared to the classical "single scattering" intensity and the classical result was found to represent only the first three terms in the total intensity expansion. The Foldy approximation to the mean field was applied to develop the coherent intensity, and was found to exactly represent all coherent terms of the total intensity. An incoherent intensity term, secular in L, in path length, was found which was not accounted for in the Foldy approximation result or in the "single scattering" formulation. Ippolito's study demonstrated the feasibility of using discrete random media techniques for the determination of multiple scattering effects in propagation through a volume of discrete scatterers, and has provided some insight to the more general problem of multiple scattering in a rain volume.

L. Ippolito[70] chaired a meeting on the 20 and 30 GHz experiments with the ATS-6 satellite. A number of interesting papers on the attenuation and depolarization of 20 and 30 GHz radiation was presented at that meeting.

2.4 Scattering and Attenuation by Snow

The scattering of radiation by snow is different than the scattering by rain in that the dielectric constant of ice is much less than that of water, and that the ice particle making up snow is distinctly nonspherical.

M. D. Blue[71] of Georgia Tech measured the permittivity of water and ice at 97-103 GHz by a reflectivity measurement of water and ice relative to mercury. He found that the reflectivity of water was:

$R = 0.392 \pm .014$ for 103.8 GHz radiation,

thus $n - ik = 3.24 - 1.825i$ for the index of refraction for water

and $\varepsilon' - i\varepsilon'' = 7.16 - 11.825i$ for water's dielectric constant.

He also measured the reflectivity of water at temperatures from 32°C to 47°C at 103.8 GHz, though no sets of terms for Debye's equation were given, as a function of temperature. The index of refraction of ice at 99 GHz was found to be $1.7 \pm .08$, real, within experimental measuring ability.

The literature on scattering and attenuation by snow in the millimeter wave range is very sparse. Malinkin, Sokolov and Sukhonin[58] measured the attenuation due to snow at 8.6 mm wavelength. Their result, in dB/km vs snowfall rate in mm/hr is shown here as Fig. 47. They concluded that the attenuation in dry snow is 2.5-5 times smaller than the attenuation in rain of the same intensity. Reference 58 includes a reference list of 11 articles.

Yu. S. Babkin et al.[72] measured the attenuation of radiation at a wavelength of 0.96 mm in snow, with a vertical polarization, and a 680 m path length. The following empirical relation was found to fit the mean attenuation in dB/km vs snowfall rate in mm/hr,

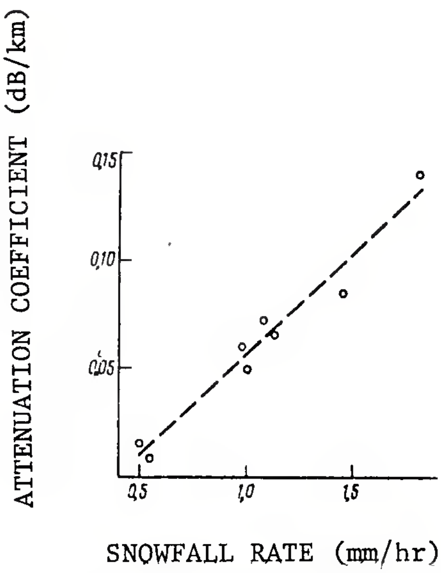


Fig. 47. Measured Attenuation Coefficient at λ=8.6 mm vs Snowfall Rate (for a Snow Density of $\rho \simeq 0.008$ gm/cm^3). Dashed Curve Gives Averaged Experimental Data (from Ref. 58)

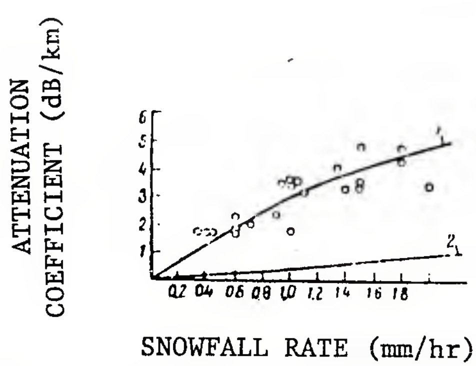


Fig. 48. Comparison of Measured and Calculated Attenuation Coefficient in Snow vs Snowfall Rate for λ=0.96 mm (Curve 1 and Points are Experimental Data, Curve 2 is Based on Mie Computations) (Data from Ref. 72)

$$\gamma \text{ (dB/km)} = 3.02 \; I^{.79}$$

where $\quad I$ = snowfall rate per mm/hr.

When the authors of Ref. 72 tried to analyze the measured attenuation data with the use of Mie theory, they obtained results that disagreed with the measurements by a factor of about 3. They assumed that the ice index of refraction was 1.78-0.00024i, and estimated that a homogenous mixture of ice, water and air (making up snow) would have an index of refraction of

$$m_s = 1.052 - 0.00012i \text{ for } \lambda = 0.96 \text{ mm.}$$

They assumed that an equivalent volume of snow (melting ice) would have a density of 0.07 gm cm^{-3}. They calculated an attenuation coefficient related to that of water of the same wavelength. Doing this, they found that attenuation in rainfalls is 30 - 40% less than in snow of the same equivalent water content. Babkin's data on snowfall attenuation in dB/km vs snowfall rate is shown in Fig. 48.

2.5 Attenuation by Ozone in the Atmosphere

Ozone is an atmospheric constituent that manifests itself most at higher altitudes except during thunderstorms, lightning, etc., and in and around arcking electronic devices (brush type motors).

The most comprehensive article on the millimeter wave spectrum of ozone is by M. Lichtenstein, J. Gallagher, and S. A. Clough.[73] They used a Stark effect spectrometer and measured absorption lines for frequencies between 9.2 to 320 GHz. Results of their absorption measurements are given in Table XXXII. Note that the strongest lines (where the intensity is more than $5 \times 10^{-4} \times 10^{-19}$ $cm^{-1}/molecule/cm^2$) occur at frequencies higher than 230 GHz.

A. Barbe, C. Secroun et al.,[74] more recently (1977) remeasured some of the absorption lines of ozone in the 15-80 GHz region; their

Table XXXII. O_3 Pure Rotational Ground Vibrational State Transitions (Data from Ref. 73)

Upper State J	K_A	K_C	Lower State J	K_A	K_C	Obs. Frequency MHz	Calc. Frequency MHz	Obs.-Calc. MHz	Intensity 296°K 10^{-19} cm^{-1}/ Molec/cm^2
21	2	20	20	3	17	9201.	9200.34	0.66	0.0000002
10	1	9	9	2	8	10226.	10225.55	0.45	0.0000003
4	0	4	3	1	3	11073.	11072.38	-0.38	0.0000004
23	4	20	24	3	21	14866.	14866.45	-0.45	0.0000004
27	3	25	26	4	22	16163.	16162.58	0.42	0.0000004
18	3	15	19	2	18	23961.	23959.66	0.34	0.0000014
39	6	32	38	5	35	25511.	25511.08	-0.08	0.0000002
16	2	14	17	1	17	25643.	25650.89	0.11	0.0000006
36	3	33	37	2	36		27439.81		0.0000001
41	5	37	40	6	34	27862.	27861.35	-0.35	0.0000002
24	4	20	25	3	23	28960.	28960.36	-0.36	0.0000015
15	3	13	16	2	14	30052.	30051.85	0.15	0.0000026
14	2	12	15	1	15	30181.	30181.15	-0.15	0.0000014
18	2	16	19	1	19	30525.	30523.94	0.06	0.0000008
23	2	22	22	3	19	36023.	36021.95	0.05	0.0000023
18	2	16	17	3	15	37832.	37832.38	-0.38	0.0000042
33	2	32	32	3	29		39437.25		0.0000005
1	1	1	2	0	2	42832.62	42832.49	0.13	0.0000018
12	2	10	13	1	13	43654.	43653.24	-0.24	0.0000035
37	6	32	38	5	33		43954.56		0.0000008
20	2	18	21	1	21		44471.08		0.0000013
30	5	25	31	4	28		50034.82		0.0000026
35	4	32	34	5	29		51053.16		0.0000018
26	3	23	25	4	22	51975.73	51976.[illegible]	-0.25	0.0000045
49	6	44	48	7	41		51981.00		0.0000002
7	2	6	8	1	7	53698.15	53698.28	-0.13	0.0000068
25	2	24	24	3	21	55354.56	55354.51	0.05	0.0000043
44	7	37	45	6	40		56973.57		0.0000004
29	3	27	28	4	24		58094.11		0.0000044
31	2	30	30	3	27		58410.52		0.0000017
29	5	25	30	4	26	61347.54	61347.33	0.21	0.0000042
51	8	44	52	7	45		61429.07		0.0000001
16	3	13	17	2	16	61926.86	61926.78	0.08	0.0000099
34	4	30	33	5	29		63078.75		0.0000031
10	2	8	11	1	11	65236.15	65236.08	0.07	0.0000083
27	2	26	26	3	23		66058.43		0.0000046
29	2	28	28	3	25		67249.37		0.0000034
6	0	6	5	1	5	67356.24	67356.13	0.11	0.0000222
49	3	47	48	4	44		67836.09		0.0000001
22	2	20	23	1	23		68421.95		0.0000020
39	3	35	39	2	38		73921.59		0.0000005
42	5	37	41	6	36		75847.61		0.0000014
22	4	18	23	3	21	76393.52	76393.46	0.06	0.0000119
12	1	11	11	2	10	76533.76	76533.56	0.20	0.0000226
21	4	18	22	3	19		77602.44		0.0000130
36	6	30	37	5	33		78993.19		0.0000029
43	5	39	42	6	36		80840.04		0.0000013
43	7	37	44	6	38		81292.09		0.0000009
50	8	42	51	7	45		90008.01		0.0000003
50	6	44	49	7	43		91029.25		0.0000004
8	2	6	9	1	9	93844.35	93844.37	-0.02	0.0000165

Table XXXII. (Continued)

Upper State J	K_A	K_C	Lower State J	K_A	K_C	Obs. Frequency MHz	Calc. Frequency MHz	Obs.-Calc. MHz	Intensity 296°K 10^{-19} cm^{-1}/ Molec/cm^2
13	3	11	14	2	12	93955.05	93955.23	-0.18	0.0000236
31	3	29	30	4	26	95796.40	95796.59	-0.19	0.0000096
2	1	1	2	0	2	96228.34	96228.39	-0.05	0.0000429
37	4	34	36	5	31		99247.20		0.0000052
24	2	22	25	1	25		100437.45		0.0000029
35	6	30	36	5	31		100691.98		0.0000052
4	1	3	4	0	4	101736.87	101736.73	0.14	0.0000815
28	5	23	29	4	26	101835.42	101835.17	0.25	0.0000126
14	3	11	15	2	14	103878.39	103878.39	0.	0.0000280
51	6	46	50	7	43		106618.30		0.0000005
20	2	18	19	3	17	109559.33	109559.26	0.07	0.0000349
47	3	45	46	4	42		110761.36		0.0000005
6	1	5	6	0	6	110836.04	110835.87	0.17	0.0001273
42	7	35	43	6	38		111049.06		0.0000021
5	2	4	6	1	5	114979.20	114979.30	-0.10	0.0000202
49	8	42	50	7	43		116177.79		0.0000006
1	1	1	0	0	0	119364.34	119364.49	-0.15	0.0000265
27	5	23	28	4	24	119277.60	119277.50	0.10	0.0000167
28	3	25	27	4	24	123349.10	123349.48	-0.38	0.0000238
9	1	7	8	0	8	124087.46	124087.28	0.18	0.0001635
8	0	8	7	1	7	125389.58	125389.28	0.30	0.0001079
20	4	16	21	3	19	125413.19	125413.20	-0.01	0.0000346
40	3	37	41	2	40		127717.94		0.0000008
33	3	31	32	4	28	128094.82	128094.99	-0.17	0.0000132
6	2	4	7	1	7	128313.85	128313.94	-0.09	0.0000254
36	4	32	35	5	31	130954.81	130954.72	0.09	0.0000105
34	6	28	35	5	31		132385.37		0.0000101
45	5	41	44	6	38		133040.90		0.0000026
41	7	35	42	6	36		136339.94		0.0000036
19	4	16	20	3	17	136960.24	136960.24	0.	0.0000426
44	5	39	43	6	38		139540.53		0.0000034
26	2	24	27	1	27		140767.61		0.0000038
10	1	9	10	0	10	142175.12	142174.97	0.15	0.0002522
45	3	43	44	4	40		143888.08		0.0000015
48	8	40	49	7	43		143966.96		0.0000010
39	4	36	38	5	33		144910.65		0.0000083
14	1	13	13	2	12	144919.44	144919.18	0.26	0.0000944
12	3	9	13	2	12	148744.85	148744.95	-0.10	0.0000542
52	6	46	51	7	45		151986.17		0.0000008
35	3	33	34	4	30	153724.19	153724.08	0.11	0.0000141
26	5	21	27	4	24	153953.29	153953.06	0.23	0.0000333
11	3	9	12	2	10	154046.43	154046.56	-0.13	0.0000565
33	6	29	34	5	29	156106.80	156107.17	-0.37	0.0000156
53	6	48	52	7	45		161099.24		0.0000008
40	7	33	41	6	36		164772.09		0.0000060
3	1	3	2	0	2	164951.82	164951.80	0.02	0.0001016
12	1	11	12	0	12	165784.45	165784.33	0.12	0.0003336
43	3	41	42	4	38		165584.65		0.0000032
60	7	53	59	8	52		166801.40		0.0000001
4	2	2	5	1	5	167572.71	167572.81	-0.10	0.0000275
47	8	40	48	7	41		170303.47		0.0000017
37	3	35	36	4	32		171412.46		0.0000124
3	2	2	4	1	3	173485.53	173485.60	-0.07	0.0000209
25	5	21	26	4	22	175186.35	175186.28	0.07	0.0000459
18	4	14	19	3	17	175445.65	175445.71	-0.06	0.0000704
41	3	39	40	4	36		178576.65		0.0000059
39	3	37	38	4	34		180001.07		0.0000093
47	5	43	46	6	40		183964.63		0.0000035
10	0	10	9	1	9	184378.31	184377.63	0.68	0.0002972
22	2	20	21	3	19	184748.84	184748.81	0.03	0.0000968
32	6	26	33	5	29	185556.91	185557.04	-0.13	0.0000244

Table XXXII. (Continued)

Upper State J	Upper State K_A	Upper State K_C	Lower State J	Lower State K_A	Lower State K_C	Obs. Frequency MHz	Calc. Frequency MHz	Obs.-Calc. MHz	Intensity 296°K 10^{-19} cm^{-1}/Molec/cm^2
41	4	38	40	5	35		187132.45		0.0000102
42	3	39	43	2	42		187633.43		0.0000011
28	2	26	29	1	29		187985.35		0.0000045
39	7	33	40	6	34		190574.46		0.0000092
17	4	14	18	3	15	193351.30	193351.17	0.13	0.0000862
14	1	13	14	0	14	195430.51	195430.20	0.31	0.0004254
10	3	7	11	2	10	195721.19	195721.27	-0.08	0.0000822
46	8	38	47	7	41		197536.21		0.0000027
30	3	27	29	4	26		199384.77		0.0000535
53	9	45	54	8	46		203367.90		0.0000006
38	4	34	37	5	33		203452.87		0.0000198
24	5	19	25	4	22		206131.95		0.0000669
46	5	41	45	6	40		207482.22		0.0000054
5	1	5	4	0	4	208642.44	208642.33	0.11	0.0002407
31	6	26	32	5	27	210423.10	210423.14	-0.04	0.0000345
2	2	0	3	1	3		210762.38		0.0000131
9	3	7	10	2	8	210803.80	210803.36	0.44	0.0000870
16	1	15	15	2	14		214955.48		0.0002320
55	6	50	54	7	47		215129.44		0.0000009
54	6	48	53	7	47		215483.75		0.0000011
38	7	31	39	6	34		218120.19		0.0000138
45	8	38	46	7	39		223900.19		0.0000041
43	4	40	42	5	37		224853.28		0.0000105
16	4	12	17	3	15		226054.12		0.0001163
59	4	56	58	5	53		228322.69		0.0000002
23	5	19	24	4	20		229574.88		0.0000869
16	1	15	16	0	16		231281.25		0.0005224
49	5	45	48	6	42		232984.27		0.0000039
16	2	14	16	1	15		235709.64		0.0007527-
14	2	12	14	1	13		237146.00		0.0007264-
30	6	24	31	5	27		238431.95		0.0000483
18	2	16	18	1	17		239093.03		0.0007685-
30	2	28	31	1	31		240905.00		0.0000049
12	2	10	12	1	11		242318.60		0.0006839-
12	0	12	11	1	11	243453.70	243453.57	0.13	0.0006180-
37	7	31	38	6	32		244147.00		0.0000195
8	3	5	9	2	8	244158.04	244158.54	-0.50	0.0001006
15	4	12	16	3	13	247761.22	247761.85	-0.63	0.0001372
20	2	18	20	1	19	248183.32	248183.14	0.18	0.0007787
7	1	7	6	0	6		249788.46		0.0004537
10	2	8	10	1	9		249961.90		0.0006201-
44	8	36	45	7	39		250731.11		0.0000061
44	3	41	45	2	44		252324.69		0.0000012
45	4	42	44	5	39		256885.65		0.0000094
22	5	17	23	4	20		258202.06		0.0001141
8	2	6	8	1	7		258716.10		0.0005325-
24	2	22	23	3	21		262858.07		0.0001877
22	2	20	22	1	21		263692.36		0.0007858-
29	6	24	30	5	25		263886.06		0.0000642
57	4	54	56	5	51		264325.31		0.0000005
7	3	5	8	2	6		264926.05		0.0000997
6	2	4	6	1	5		267266.54		0.0004211
57	6	52	56	7	49		268319.85		0.0000009
36	7	29	37	6	32		271092.80		0.0000271
18	1	17	18	0	18		273050.63		0.0006176-
4	2	2	4	1	3		274478.42		0.0002866
14	4	10	15	3	13	276923.78	276923.62	0.16	0.0001653
43	8	36	44	7	37		277042.33		0.0000087
51	5	47	50	6	44		279332.66		0.0000038
48	5	43	47	6	42		279467.41		0.0000069
2	2	0	2	1	1	279485.90	279485.78	0.12	0.0001209

Table XXXII. (Continued)

Upper State J	K_A	K_C	Lower State J	K_A	K_C	Obs. Frequency MHz	Calc. Frequency MHz	Obs.-Calc. MHz	Intensity 296°K cm^{-1} Molec/cm^2
32	3	29	31	4	28	279893.48	279893.03	0.45	0.0000892
40	4	36	39	5	35		280994.06		0.0000289
47	4	44	46	5	41		281958.91		0.0000075
56	6	50	55	7	49		282129.63		0.0000013
21	5	17	22	4	18	282837.66	282837.04	0.62	0.0001411
18	1	17	17	2	16	286087.20	286087.52	-0.32	0.0004445
24	2	22	24	1	23	286156.50	286156.31	0.19	0.0007893
3	2	2	3	1	3	286294.20	286294.71	-0.51	0.0002129
9	1	9	8	0	8	288958.95	288959.01	-0.06	0.0007454
55	4	52	54	5	49		289389.72		0.0000011
28	6	22	29	5	25		290974.95		0.0000841
5	2	4	5	1	5	293171.25	293171.29	-0.04	0.0003722
6	3	3	7	2	6		293548.42		0.0000961
35	7	29	36	6	30		297173.58		0.0000365
32	2	30	33	1	33		298601.92		0.0000050
49	4	46	48	5	43		298796.19		0.0000054
13	4	10	14	3	11	300685.80	300685.24	0.56	0.0001856
14	0	14	13	1	13	301812.48	301812.76	-0.28	0.0010742
7	2	6	7	1	7	303163.20	303164.85	-1.60	0.0005187
53	4	50	52	5	47		303289.78		0.0000020
42	8	34	43	7	37		303573.61		0.0000121
51	4	48	50	5	45		306222.56		0.0000035
20	5	15	21	4	18	310062.72	310063.36	-0.64	0.000173[illegible]
26	2	24	26	1	25	315874.47	315874.94	-0.47	[illegible]787[illegible]
9	2	8	9	1	9		316327.04		0.0006555
27	6	22	28	5	23		316681.45		0.0001066
5	3	3	6	2	4		317195.13		0.0000811
20	1	19	20	0	20		319996.27		0.000703[illegible]

new results are presented here as Tables XXXIII and XXXIV. Table XXXIII is for rotational lines of O_3 in the ν_1 (ground) state and Table XXXIV is for rotational lines of O_3 in the ν_3 (ground) state.

A spacecraft instrument was developed for the measurement of the mm characteristics of ozone by personnel at the Ewin Knight Company.[75] They chose a line at 101.7 GHz for radiometrically measuring the emitted radiation of the air mass beneath the spacecraft. Reference 75 describes the design of the instrument from concept phase, laboratory phase, through a balloon-mounted instrument, and to a spacecraft flight instrument. Canton, Manneller et al.[78] define the ozone absorption coefficient as:

$$\alpha_{oz} = \frac{A_1 e^{-A_s/T}}{T^{5/2}} \; NO_3 \cdot \nu^2 \left[\frac{\Delta\nu}{(\nu - A_3)^2 + (\Delta\nu)^2} + \frac{\Delta\nu}{(\nu + A_3)^2 + (\Delta\nu)^2} \right]$$

where

$$\Delta\nu = \left[\left[A_4 P T^{-1/2}\right]^2 + \left[A_5 T^{1/2}\right]^2 \right]^{1/2}$$

For the 101.7 GHz transition,

$$A_1 = 1.2 \times 10^{-24} \mathrm{km}^{-1}; \; A_2 = 13.1°\mathrm{K}; \; A_3 = 101.7368 \times 10^4 \mathrm{Hz}$$

$$A_4 = 5.28 \times 10^7 \mathrm{Hz} \; (°\mathrm{K}^{1/2}) \; \mathrm{mm}^{-1}, \quad A_5 = 7.31 \times 10^3 (°\mathrm{K})^{-1/2}$$

These constants A_1, A_2, A_3, A_4 and A_5 are from Gora,[76] and Townes and Schawlow.[77] A comparison of measured absorption profile data taken with use of the instrument described in Ref. 75 and calculated absorption profiles based on the above equation is shown in Fig. 49.

Table XXXIII. Rotational Lines of $^{16}O_3$ in the ν_1 State (Data from Ref. 74)

lower J	lower K_{-1}	lower K_{+1}	upper J	upper K_{-1}	upper K_{+1}	calc. (MHz)	Obs. (MHz)
1	1	1	2	0	2	43059.674	43059.910
4	0	4	3	1	3	10518.195	10518.320
6	0	6	5	1	5	66332.847	66333.070
7	2	6	8	1	7	56322.535	56322.620
10	2	8	11	1	11	60569.033	60569.120
12	2	10	13	1	13	36254.758	36254.790
14	2	12	15	1	15	19215.805	19215.910
15	3	13	16	2	14	36281.384	36281.440
16	2	14	17	1	17	10272.456	10272.310
16	3	13	17	2	16	60127.209	60127.340
18	3	15	19	2	18	20308.969	20309.340
18	2	16	17	3	15	29143.551	29143.300
18	2	16	19	1	19	9669.776	9669.570
22	4	18	23	3	21	77996.535	77996.306
29	5	25	30	4	26	69900.455	69901.401
25	2	24	24	3	21	69297.245	69296.890
12	1	11	11	2	10	71611.790	71611.625
23	2	22	22	3	19	45505.101	45504.288
29	3	27	28	4	24	60198.237	60198.452
30	5	25	31	4	28	54788.390	54788.333
23	4	20	24	3	21	23786.015	23786.275
24	4	20	25	3	23	29888.538	29889.336

Table XXXIV. Rotational Lines of $^{16}O_3$ in the ν_3 State (Data from Ref. 74)

lower J	lower K_{-1}	lower K_{+1}	upper J	upper K_{-1}	upper K_{+1}	calc. (MHz)	Obs. (MHz)
2	1	2	3	0	3	15664.591	15664.570
5	0	5	4	1	4	39099.335	39099.200
8	2	7	9	1	8	18673.215	18673.010
11	1	10	10	2	9	46687.931	46688.170
11	2	9	12	1	12	59371.426	59371.480
13	2	11	14	1	14	45388.259	45388.270
14	3	12	15	2	13	56314.345	56313.970
15	2	13	16	1	16	40733.576	40733.370
17	2	15	16	3	14	10705.554	10705.730
17	2	15	18	1	18	45990.313	45989.990
17	3	14	18	2	17	45322.044	45321.930
19	2	17	20	1	20	61286.619	61286.730
19	3	16	20	2	19	12594.171	12593.910
29	5	24	30	4	27	71318.362	71317.572
23	4	19	24	3	22	51441.035	51441.095
25	3	22	24	4	21	28460.893	28460.788
30	3	28	29	4	25	70678.174	70677.947
30	5	26	31	4	27	21292.446	21292.100

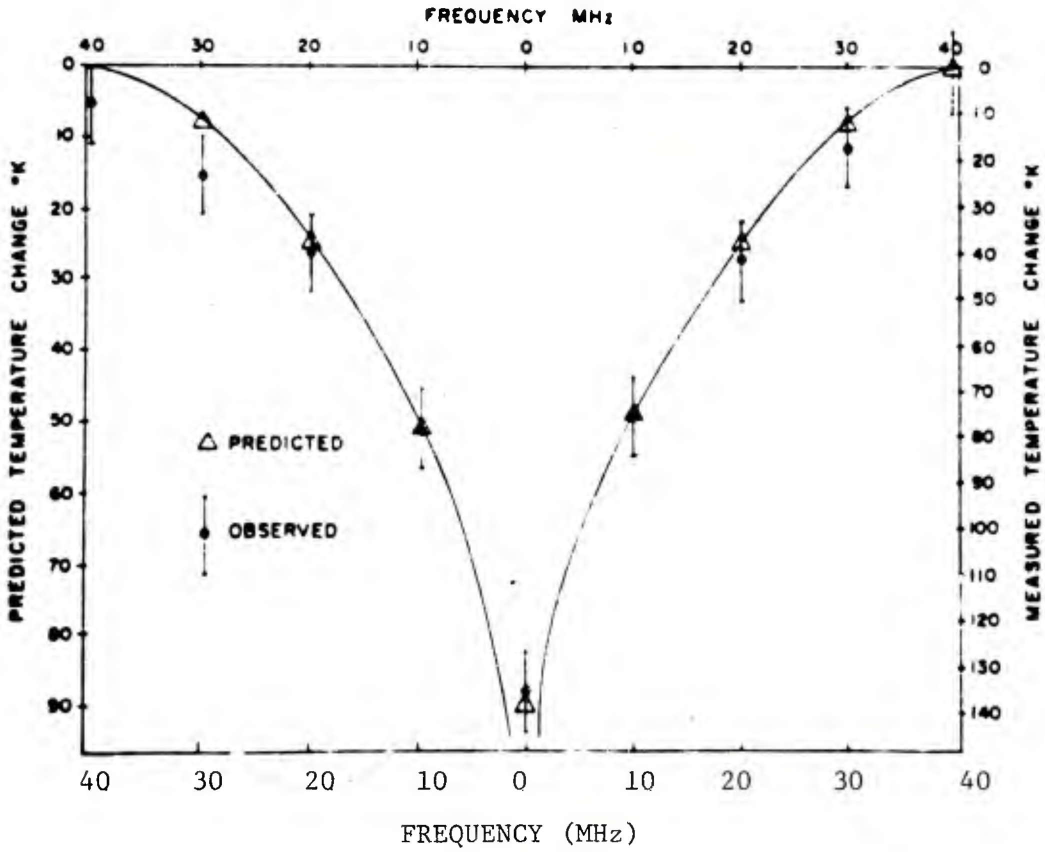


Fig. 49. Measured and Predicted Ozone Absorption Profiles Normalized to Equal Amplitude for a Background Sun Temperature of 2500 °K (Data from Ref. 75)

2.6 Attenuation and Scattering by Atmospheric Aerosols

First, let us consider just what constitutes an aerosol. Depending on where you are on the earth (or up in the stratosphere) an aerosol could mean various things.

Lendberg and Gillespie[79] at White Sands, New Mexico, collected dust samples and ran them through a fractionated dust stage to sort them out for sizes. They found that the particle composition varies as a function of their sieve pore size that allowed these dust particles to pass. The result is shown in Table XXXV. They measured the imaginary index of refraction of these dust sample stages from 0.3 μm to 1.7 μm and showed that there was a vast difference in this quantity with dust size.

The major reference on atmospheric dust and aerosols has to be the conference proceedings[80] "Atmospheric Aerosols; Their Optical Properties and Effects"; this conference was held at Williamburg, Virginia, December 13-15, 1976. K. Bullrich and G. Hänel[80] presented (Paper MH1) data on particle size distributions for different types of aerosols. Their distributions are shown in Fig. 50. They also showed that the humidity has a definite impact on the optical characteristics. The mass absorption coefficient k/ρ vs wavelength (1.0 μm to 10.0 μm) is given in Fig. 51 for 3 levels of humidity. One would expect that the humidity will also affect the absorption coefficient of aerosols at longer wavelengths.

H. E. Gerber et al. in paper TUA6[80], presented a paper on "Laser Transmissions through a Concentrated Aerosol." They used a centrifuge-type device to concentrate aerosols to simulate a light path through the cell of up to 1 km. They measured data on the transmission as a function of time for a concentrated oil aerosol and for 0.63, 1.06, 3.8 and 10.6 μm wavelength radiation. Their results are given in Fig. 52.

E. P. Shettle and F. E. Voltz,[80] in their paper MC14 "Optical Constants for a Meteoric Dust Aerosol Model" calculated the attenuation

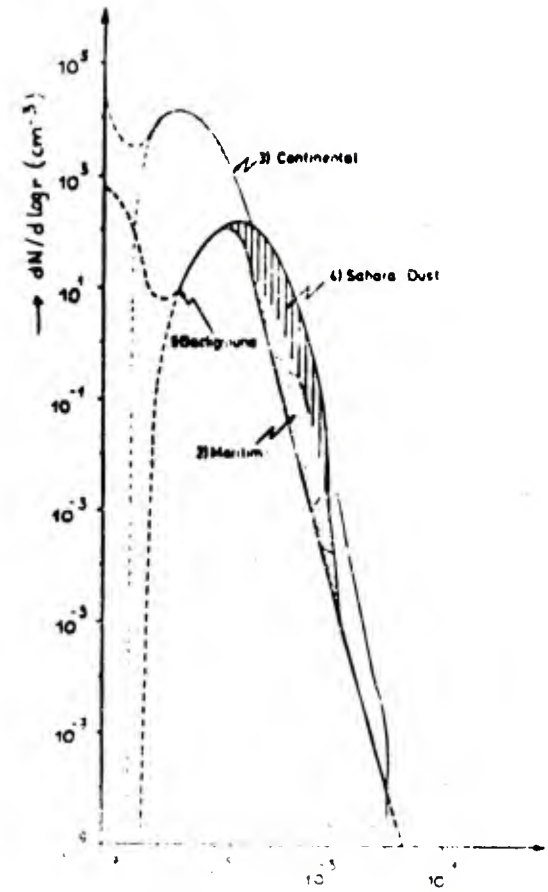
Table XXXV. Optically-Significant Components of Size Fractionated Dust Samples[a] (Data from Ref. 79)

Component	Stage number 7	6	5	4	3	2	1	0
Clay minerals[b]	—	—	X	X	X	X	X	X
Quartz		—	X	X	X	X	X	X
Calcite		—	—	X	X	X	X	X
Gypsum			X	X	—			
Ammonium sulfate	X	X	—					
Carbon[c]	X	X	—					

[a] The X indicates that the material was present; the symbol — indicates that the material was detectable but present in much lower concentration.

[b] Specifically montmorillonite, illite, and kaolin group clays.

[c] The presence of carbon was estimated by other means, as discussed in text.



RADIUS (cm)

Fig. 50. Aerosol Particle Size Distributions as Measured by Bullrich and Hänel (Ref. 80) for Continental, Sahara Dust and Maritime Hazes

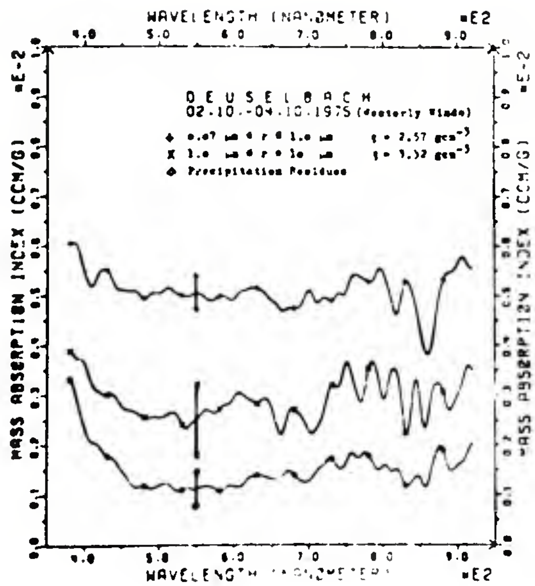


Fig. 51. Mass Absorption Cross Section, k/ρ_o, of Aerosols at Three Different Humidities (Data from Ref. 80)

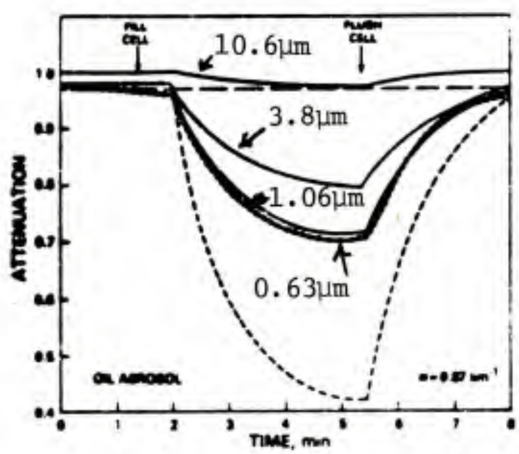


Fig. 52. Attenuation of Laser Radiation by Oil Aerosols as a Function of Time (Data from Ref. 80)

coefficient for a set of samples of meteoric dust whose reflectivity had been measured in the spectral region 2.5 to 40 μm. A 9-oscillator model was fitted to these measurements using a nonlinear least squares optimization of his sets of equations, which were:

$$Ra = \frac{(n-1)^2 + k^2}{(n+1)^2 + k^2} = \text{reflectivity}$$

$$n^2 - k^2 = A_o + \sum_j \frac{2A_j(\nu_j^2 - \nu^2)}{(\nu_j^2 - \nu^2)^2 + \gamma_j^2\nu^2}$$

$$nk = \sum_j \frac{A_j\,\gamma_j\,\nu}{(\nu_j^2 - \nu^2)^2 + \gamma_j^2\nu^2}$$

ν_j = frequency of jth oscillator

A_j = oscillator strength

γ_j = damping constant or band width

Results of their calculation of the aerosol attenuation coefficient are show in Fig 53.

James W. Fitzgerald at the Optical Submillimiter Atmospheric Propagation Conference[81] presented a paper on "Effect of Relative Humidity on Aerosol Size Distribution and Visibility-Modeling Studies." Fitzgerald derived a relationship between the relative humidity and the equilibrium size of an aerosol particle that had an insoluble core with a soluble covering in the form of a pure salt. The equilibrium saturation ratio, S, is described by

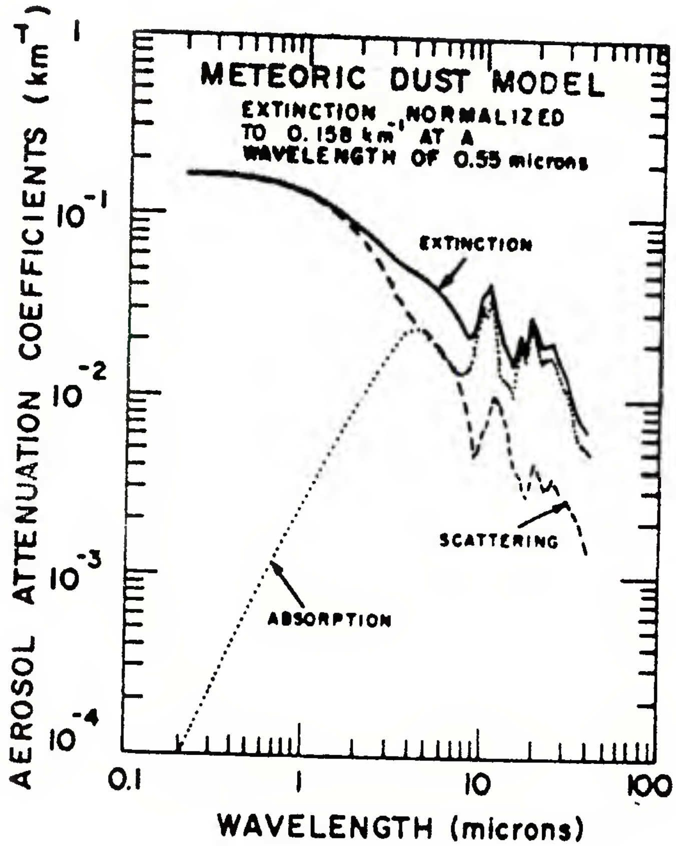


Fig. 53. Scattering, Absorption and Extinction Coefficients vs Wavelength for Meteoric Dust Model (Data from Ref. 80)

$$S = \exp\left[\frac{2\sigma'}{r\rho' R_v T}\right]\left[1 + \frac{i\,\varepsilon\rho_d\,M_w\,r_d^{\,3}}{M_s\{\rho'(r^3 - r_d^{\,3}\ (1-\varepsilon)) - \varepsilon\rho_d\,r_d^{\,3}\}}\right]^{-1}$$

where

S = equilibrium saturation ratio (% relative humidity divided by 100),

r = equilibrium radius of the particle (solution droplet)

r_d, ρ_d = radius and density of the dry particle,

M_w = molecular weight of water,

M_S = molecular weight of the soluble component,

i = Van't Hoff factor,

R_v = specific gas constant of water vapor,

ε = mass fraction of the soluble material on the dry particle

σ', ρ' = surface tension and density of the aqueous salt solution.

On a cruise off the coast of Nova Scotia, a sea-fog aerosol size distribution was measured, and compared with calculations obtained from the above model. Results of the calculations and measurements are shown in the next two figures. The first, Fig. 54, is for 10 km downwind of the formation edge of a fog, and the second, Fig. 55, is for 25 km downwind of the fog formation line. These are models that should prove useful for millimeter wave studies on sea-fog aerosols.

It is apparent that some calculations and measurements of radiation scattering by aerosol have been made for wavelengths up to 30 μm in the IR region, but no measured data were found in the .1 mm to 1 cm region.

Information on the aerosol index of refraction needs to be generated and measurements made in the submillimeter region. Experimentally, the Fourier transform spectrometer could be used to determine the complex index of refraction of a number of different types of particles.

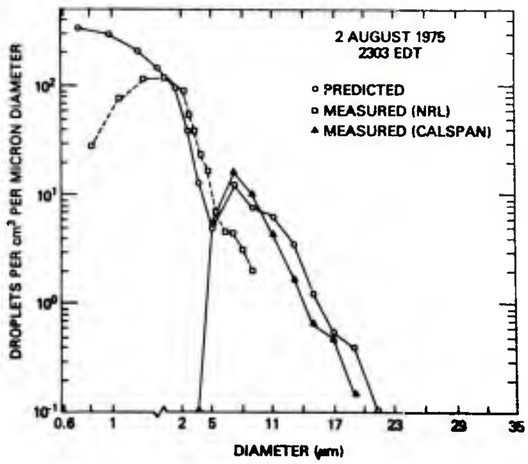


Fig. 54. Comparison of Observed and Predicted Droplet Size Distributions at a Point 10 km Downwind of the Forming Edge of the Fog on 2 August 1975 (Data from Ref. 81)

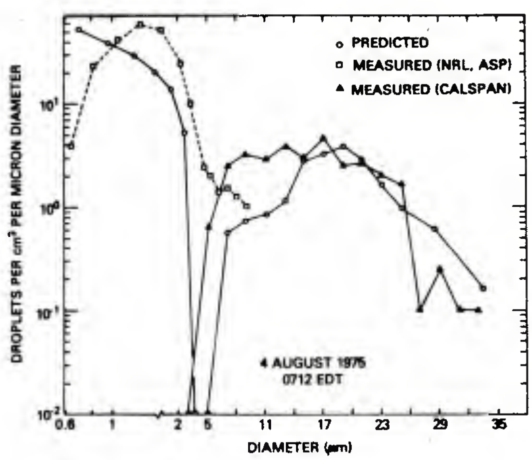


Fig. 55. Comparison of Observed and Predicted Droplet Size Distributions at a Point 25 km Downwind of the Forming Edge of the Fog of 4 August 1975 (Data from Ref. 81)

Some of the types of aerosol particles that need to be considered when making index of refraction measurements are:

Soluble Materials

$(NH_4)_2\ SO_4$

NH_4NO_2

$NaNO_3$

NH_4Cl

$CaCl_2$

NaBr

NaCl

M_9Cl_2

LiCl

$ZnCl_2$

P_2O_5

Non Soluble Materials

Clay minerals (montmorillonite, illite, and kaolin group)

Quartz

Calcite

Gypsum

Carbon

Basalt

2.7 Attenuation and Scattering by Battlefield Dusts and Smokes

The literature relating to the attenuation and scattering properties of battlefield dust and smokes in the millimeter and submillimeter wave region in very sparse.

G. Tinsley and T. Cosden[82] measured the particle size distribution of some machine-gun smoke. The particle distributions shown in Fig. 56 are one-minute averages. The "1514" time is before the smoke reached the particle counter. At 1518, the smoke had largely passed. They calculated the extinction in this smoke for 3.9 μm radiation. E. W. Stuebing, F. O. Verderame et al., in paper 14 of the conference[81], presented a talk on the "Nature of Gun Smoke and Dust Observation." They developed the data listed in Table XXXVI which gives the products of nitro-cellulose combustion from a 30 mm Rarden cannon round. Stuebing et al. also modeled an obscuring smoke cloud which they assumed was due to a combination of gun smoke and the dust created from the ground by the muzzle blast of the cannon. They calculated the optical densities at 0.5, 1.06 and 10.6 μm wavelengths that were provided by the smoke produced by the firing of a 30 mm Rarden cannon from measured transmission vs time measurements for those wavelengths. The optical density is defined by the equation $T = 0.1^D$ where T is the measured transmission and D is the optical density. Figures 57 and 58 show the measured optical density vs time for the three wavelengths used in the measurements. Also shown in these figures are the optical densities obtained from model calculations. The transmission through the smoke has two minima: the first appears to result from the smoke produced by the products of nitrocellulose combustion (which was modeled as water) and the second results from the dust created from the ground. The comparison between the model results and the measured densities for $\lambda = 0.53$ μm appears to be good. Although the data in Figs. 57 and 58 are for wavelengths in the visible and near infrared, the models giving the "smoke" particle size distribution vs time could be used with Mie theory to determine absorption, scattering and extinction coefficients for millimeter and submillimeter wavelength radiation.

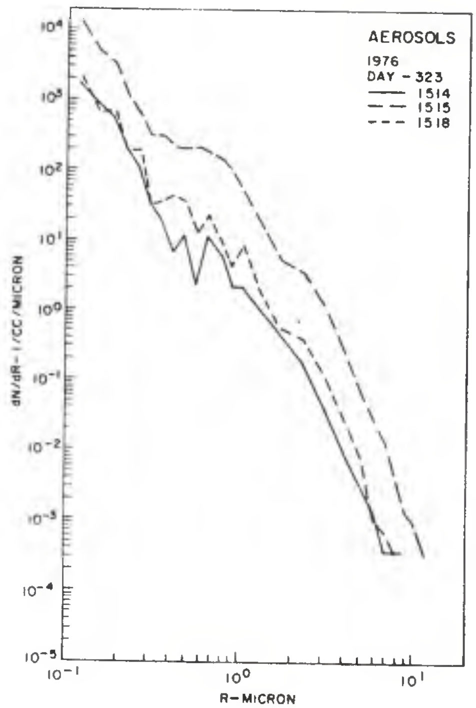


Fig. 56. Measured Particle Size Distributions for Machine-Gun Smoke; time = 1515 (Data from Ref. 82)

Table XXXVI. Products of Nitrocellulose Combustion. (from Data in Paper 14 of Ref. 81)

Major Products

CO, CO_2, H_2, H_2O (Water Gas Equilibrium)

N_2

Major Minor Products

CH_4, NH_3

Minor Minor Products

C, K_2O, SnO_2, Na_2O, BaO

(Pb, Sb, Si, Zr, Ca, Al)

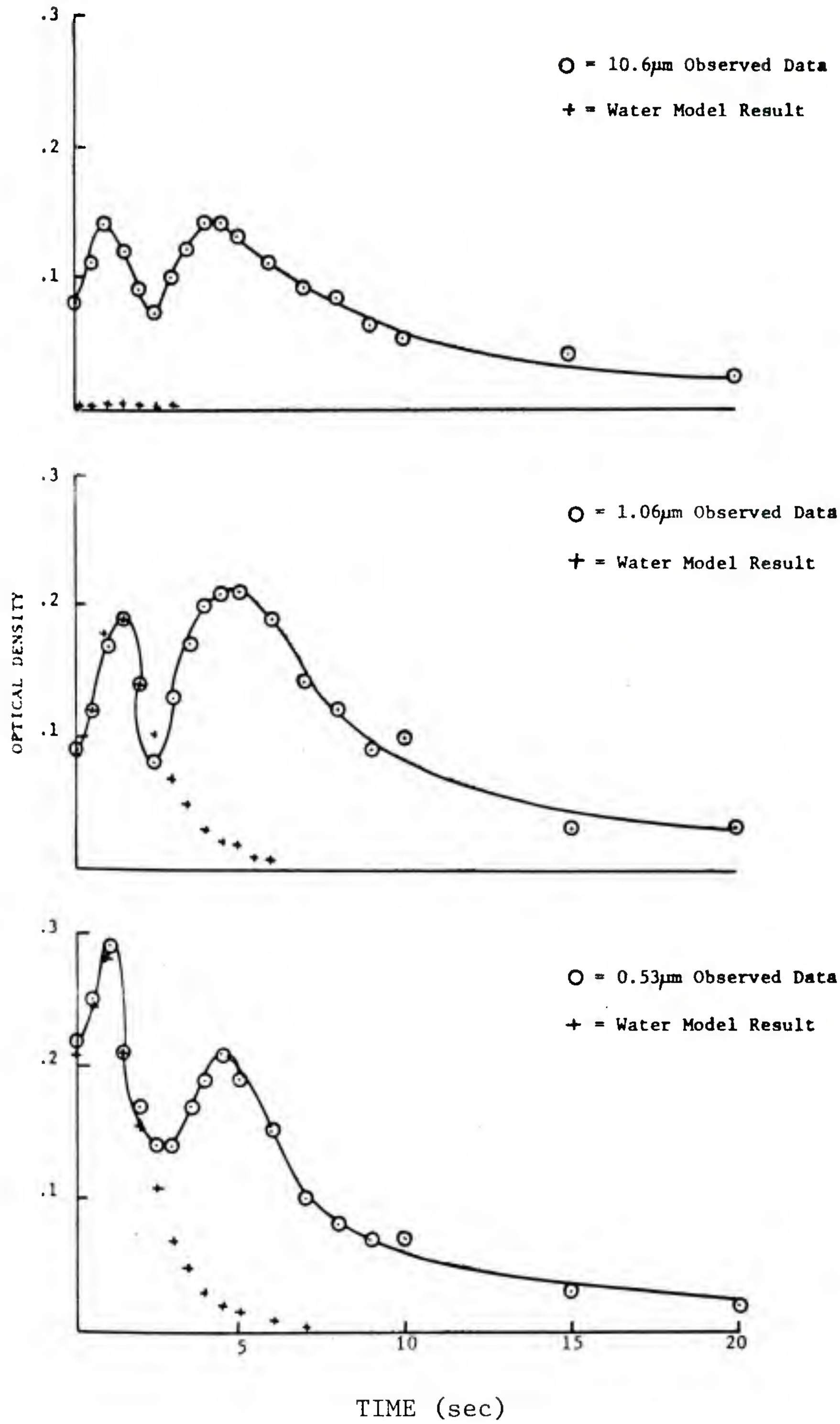


Fig. 57. Measured and Calculated Optical Density vs Time After Firing of Cannon (from Ref. 81)

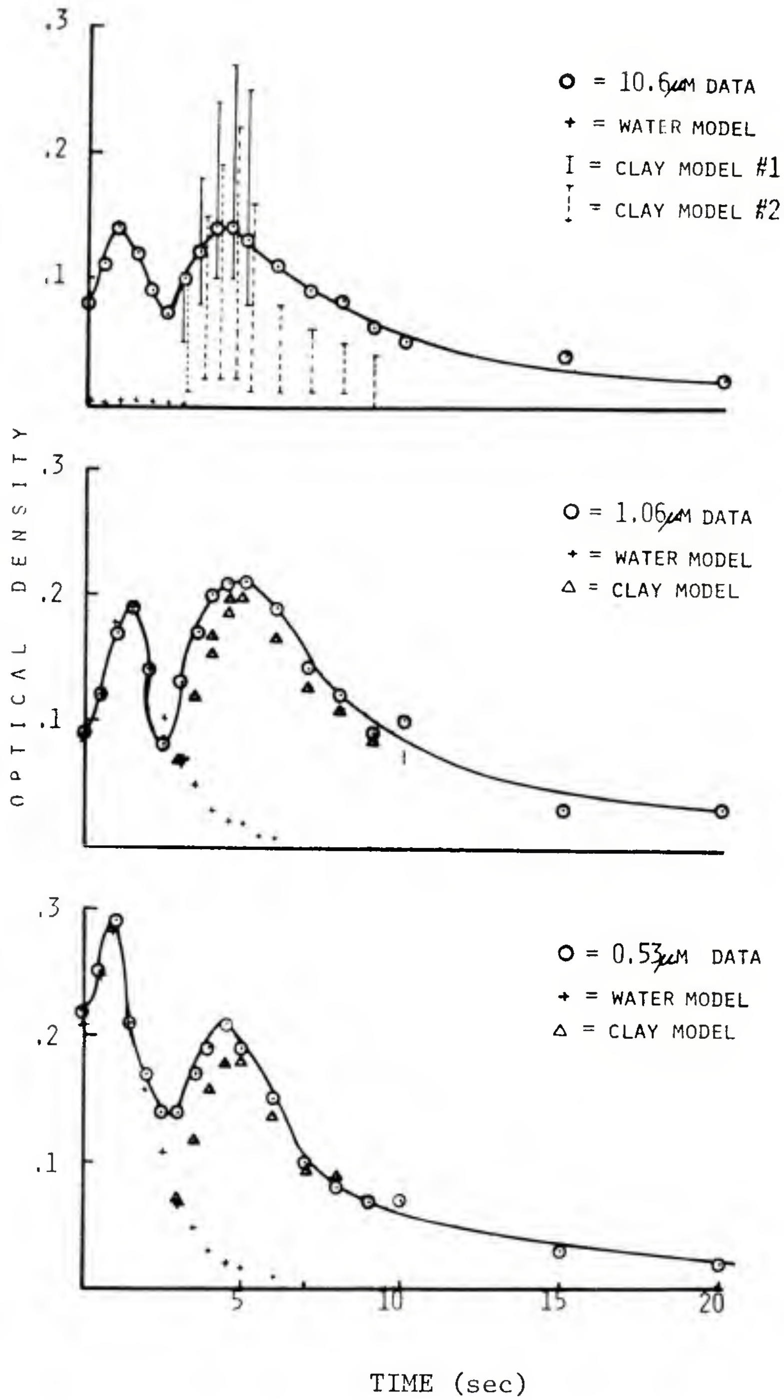


Fig. 58. Measured and Calculated Optical Density due to Gun Smoke and Dust Model (from Ref. 81)

Alan Downs in Ref. 44 has reviewed the transmission of optical radiation through smoke and dust. The transmission through several smokes for visible and 10.6 μm wavelength laser light as a function of the particle concentration is shown in Fig. 59. Further work of optical transmission in smokes is alluded to in Downs' report. Downs also reported data on transmission versus time for visible (.4 - .7μm), near IR (.7 - 1.1 μm) and IR (3-5μm and 8-14μm) radiation through 105 mm HC round caused smoke cloud (presented here as Fig. 60), a 60 mm WP morter caused smoke cloud presented here as Fig. 61) and a fog oil smoke cloud (presented here as Fig. 62). The latter fog oil cloud was produced by 9-M-7 fog oil smoke pots. Downs reported that when 94 GHz and 140 GHz radar beams were transmitted through each of these clouds, the resulting signals showed no attenuation. Table XXXVII lists the time in minutes that each of the visible and IR systems could "see" the smoke phenomena that were described in the previous three figures.

Downs also presented data on transmissions through a dust cloud that were collected at Fort Sill during smoke tests. The transmission through the cloud is shown here in Fig. 63. The reduction in transmission during the 0 - 20 second time period is due to the smoke and the cause for the transmission loss in the 123 second - 200 second time period is due to dust.

Downs also reported on another dust cloud experiment. The results obtained from the experiment are shown in Fig. 64. Downs reported that there was no apparent attenuation of 94 GHz and 140 GHz radar by the dust.

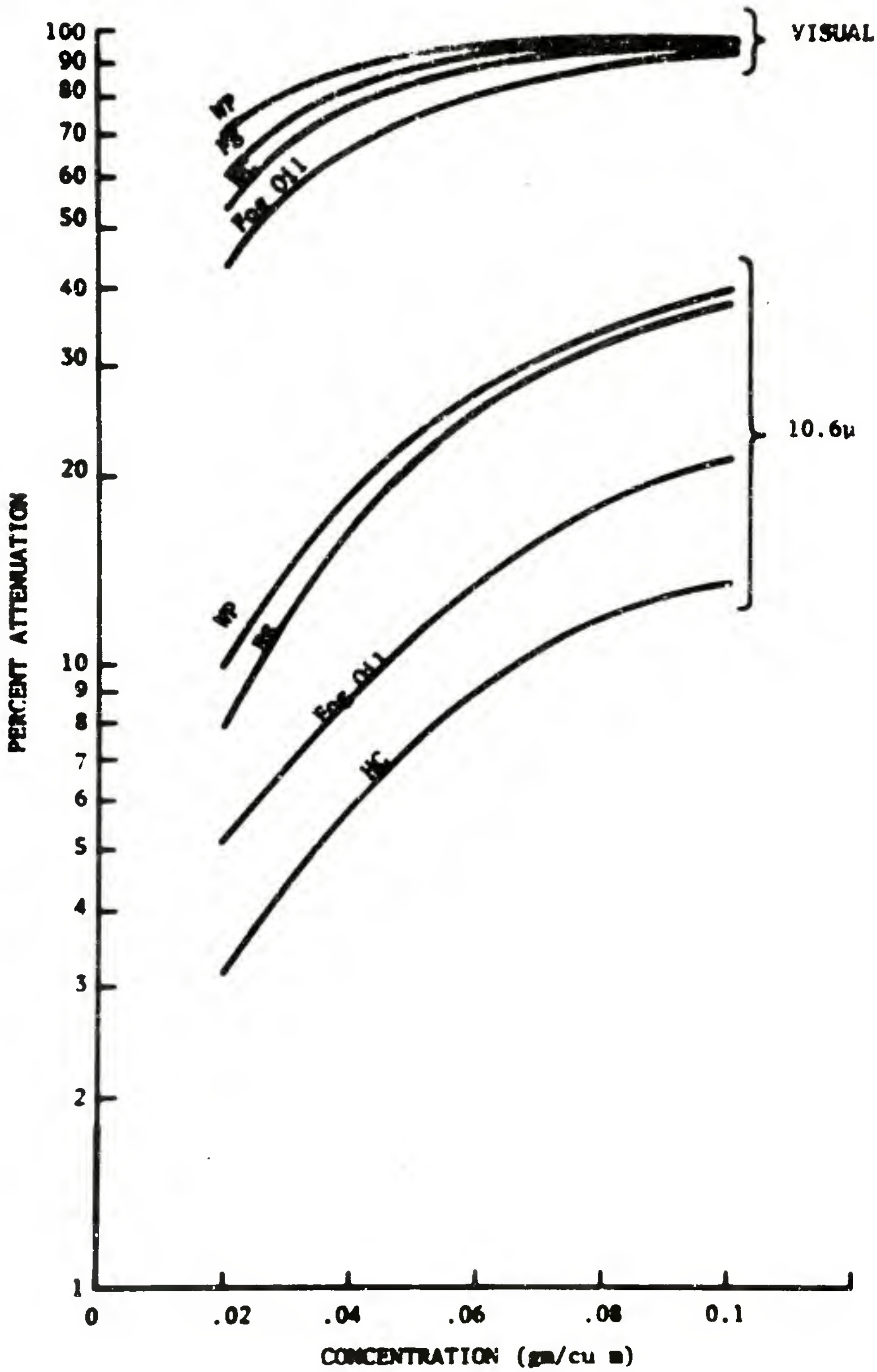


Fig. 59. Transmission through Several Smokes as a Function of Concentration for Visible Light and 10.6μm Laser Radiation (Data from Ref. 44)

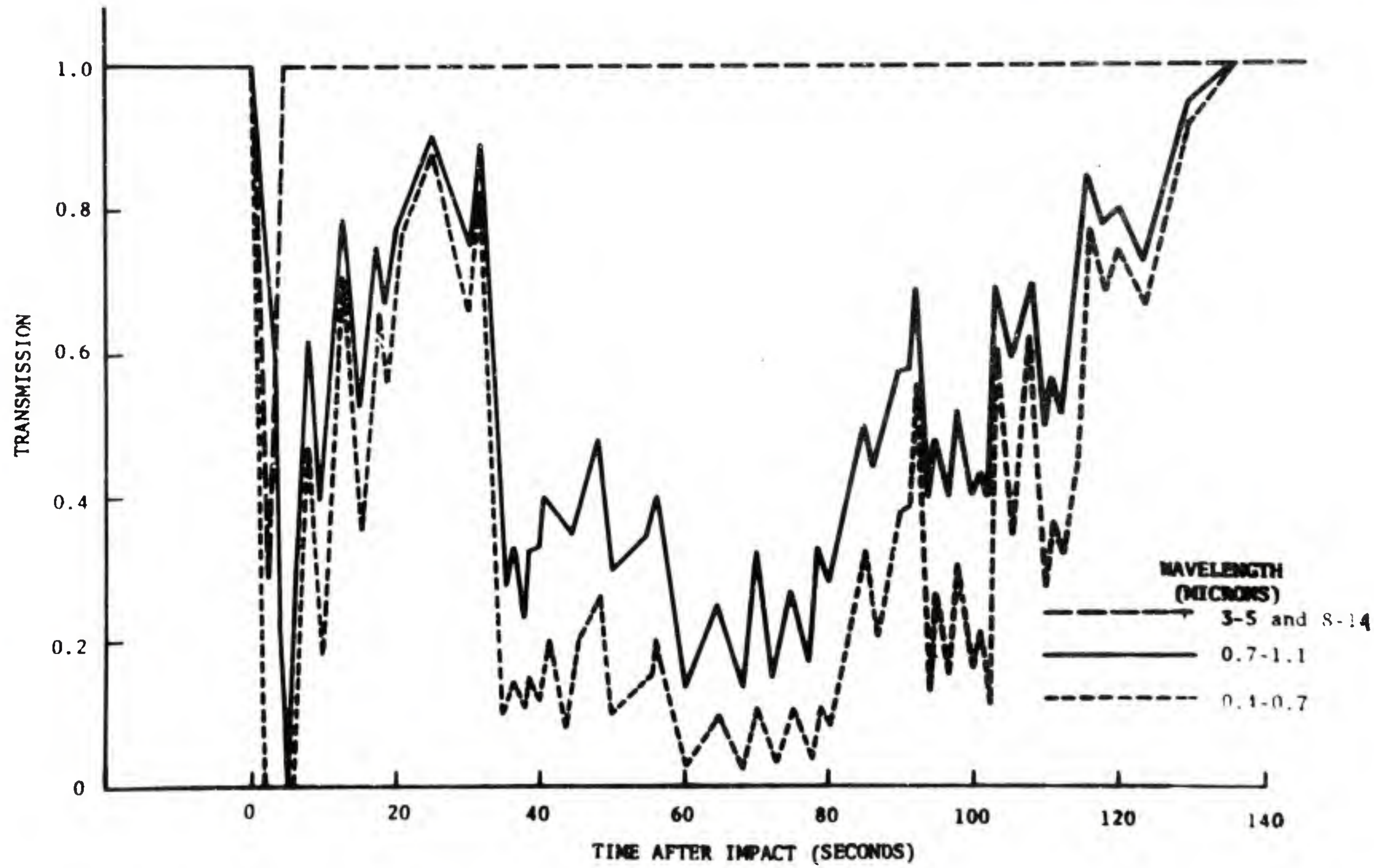


Fig. 60. Optical Transmission through an HC Smoke Cloud as a Function of Time After Impact for Indicated Wavelength Ranges (Data from Ref. 44)

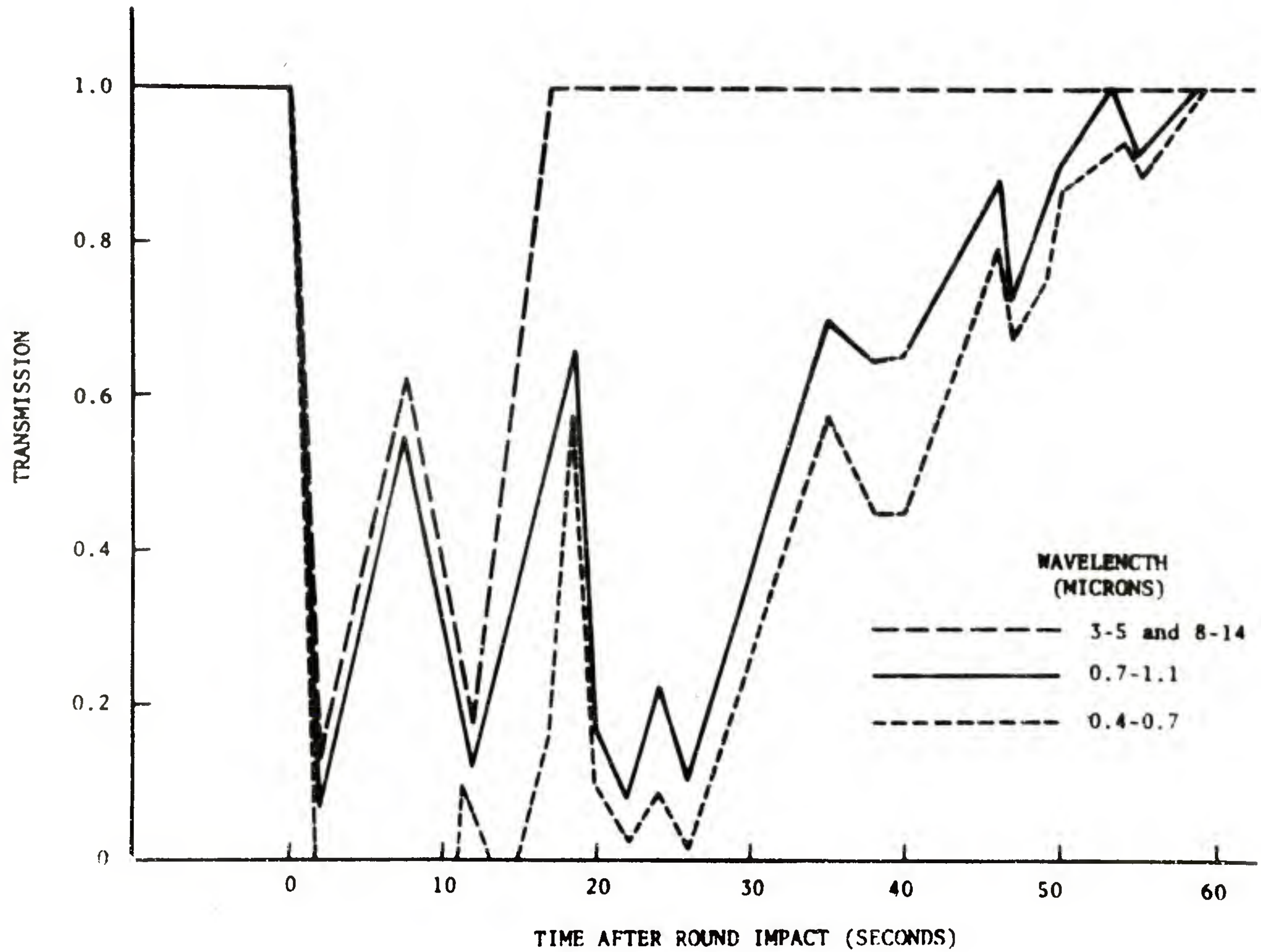


Fig. 61. Optical Transmission Through a WP Smoke Cloud as a Function of Time After Impact for Indicated Wavelength Ranges (Data from Ref. 44)

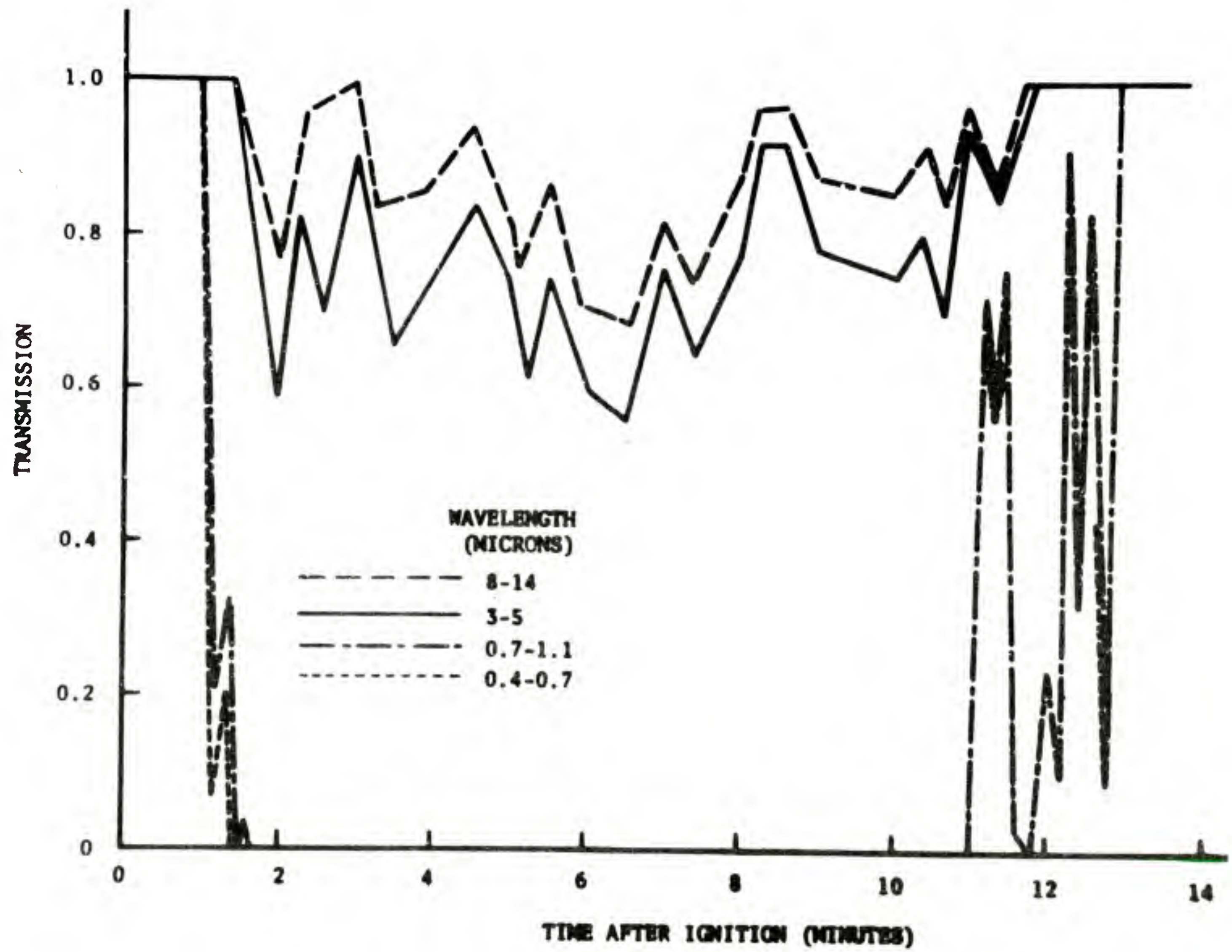


Fig. 62. Optical Transmission Through a Fog Oil Smoke Cloud as a Function of Time After Ignition for Indicated Wavelength Ranges. (Data from Ref. 44)

Table XXXVII. Time in Minutes After Production of Smoke that the Presence of the Smoke Could be Detected by Radiation in the Indicated Wavelength Ranges (Data from Ref. 44)

WAVELENGTH (MICRONS)	MEASURED QUANTITY	MUNITION TYPE			
		FOG OIL POTS	HC POTS	UK GRENADES	ROCKETS, MORTARS AND ARTILLERY PROJECTILES
0.4-0.7	Maximum Time of Total Attenuation	10	17	4	45
0.7-1.1	Maximum Time of Total Attenuation	10	17	4	43
3-5	Maximum Time of Total Attenuation	0	0	0	17
	Average Transmission	0.80	0.70	0.65	
	Minimum Transmission	0.35	0.15	0.05	0
8-14	Maximum Time of Total Attenuation	0	0	0	13
	Average Transmission	0.90	0.80	0.70	
	Minimum Transmission	0.50	0.35	0.15	0

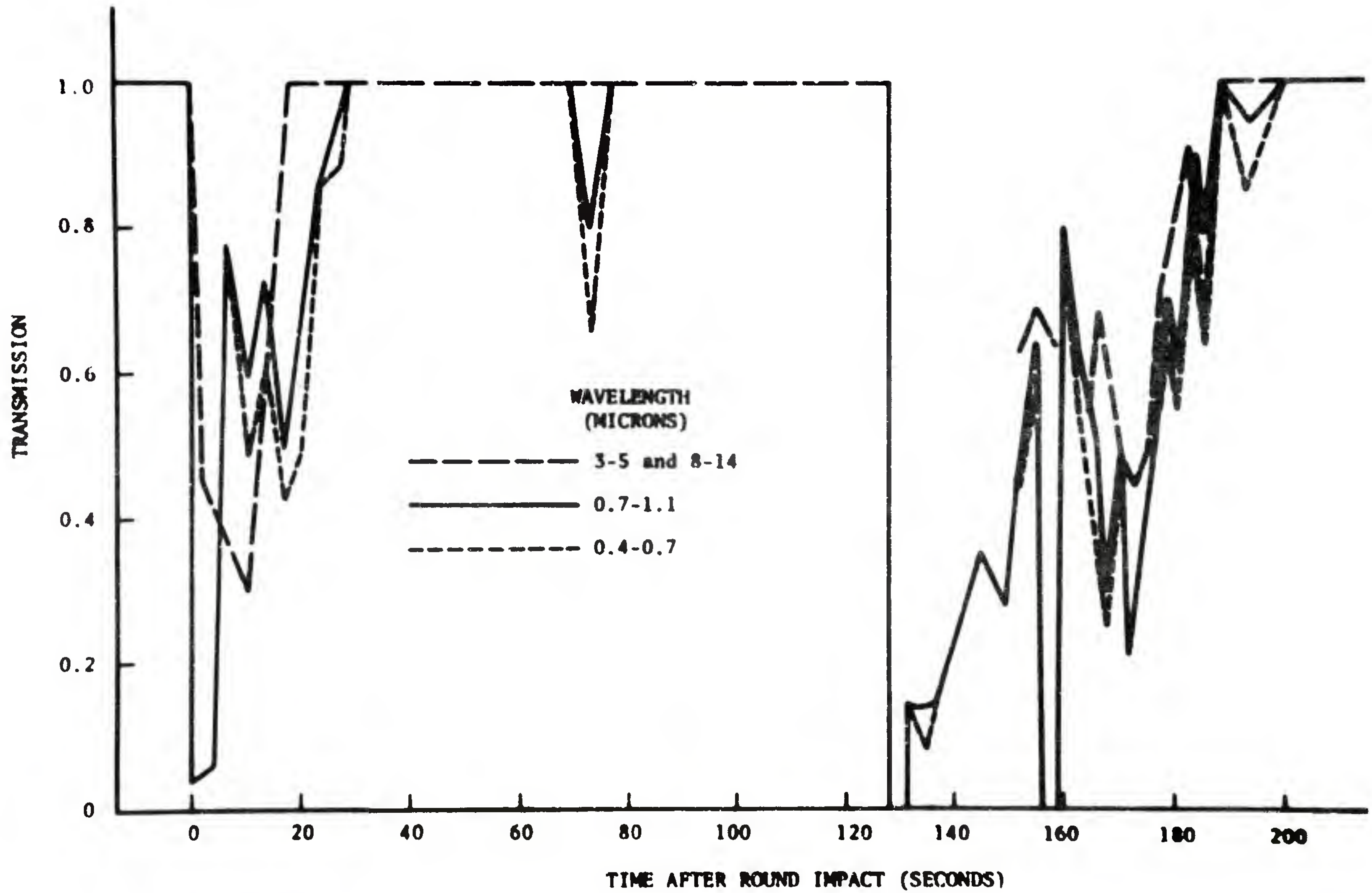


Fig. 63. Optical Transmission Through a Dust Cloud as a Function of Time after Round Impact for Indicated Wavelength Ranges (Data from Ref. 44)

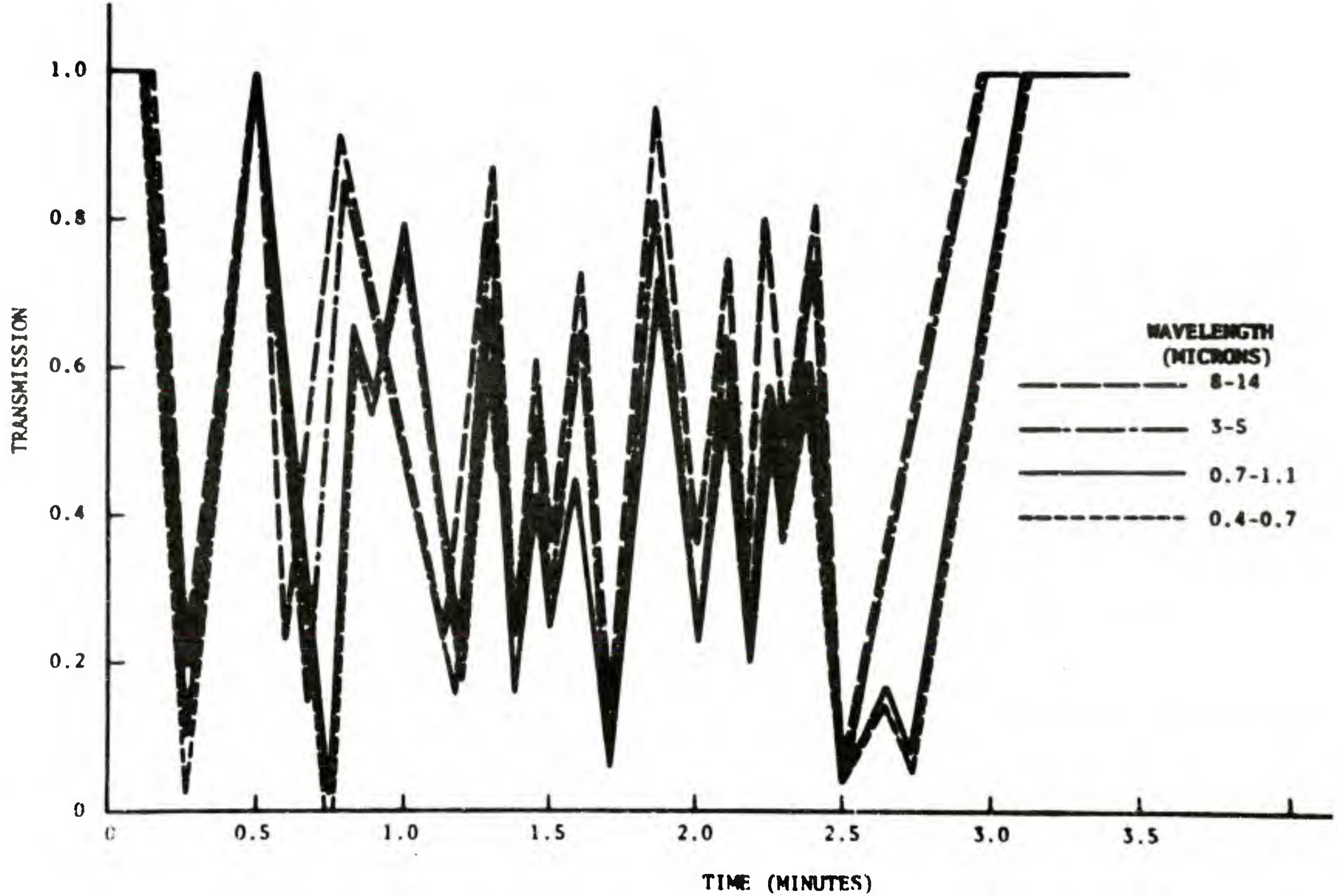


Fig. 64. Optical Transmission Through Dust Cloud as a Function of Time After Cloud Formation for Indicated Wavelength Ranges (Data from Ref. 44)

III. SUMMARY OF DOCUMENTS SURVEYED IN THE LIMITED DOCUMENT LITERATURE

Only documents that were felt worthy of mention, as containing information not found in the open literature will be discussed here. The technical areas will be along the same format as was in the unlimited version.

3.1 Attenuation and Scattering by Rain and Hail

Vogel reports in Ref. 83 on Mie theory calculations for spheres of water (rain) and ice (hail) at frequencies of 30, 100, 150 and 300 GHz. The values he used for the index of refraction for water and for ice are given in Table XXXVIII. He points out that frozen rain (hail) scatters more radiation than does liquid rain for frequencies above 150 GHz. The Russians concur with this conclusion in their articles on attenuation by snow (see Ref. 72). Richard and Kammerer[55] also points out that mm radiation scattering by ice will tend to be more peaked in the forward direction for frequencies above 100 GHz than that computed for water droplets. The single scattering of ice was found to be critically dependent on its conductivity. A number of different Mie theory calculations of the phase function for scattering are given in Ref. 55. Attenuations due to rainfall at 100 GHz based on the Mie theory calculations were compared with measurements taken by Setzer, Asari and Medhurst[61], and were found to be within the experimental error.

3.2 Attenuation by Water Vapor

Gamble and Hodgens[84] reported on a literature survey for mm waves of wavelength 0.735 - 8.57 mm. They caution about dimer effects during heavy fog (relative humidity >95%) or rain (RH >80%). Dimer effects are (H_2O) - (H_2O) interactions that tend to broaden the water vapor absorption

Table XXXVIII. Index of Refraction of Water and Ice
(Data from Ref. 84)

Frequency (GHz)	State	Index of Refraction
30	Water 20°C	5.9 - 2.9i
	Ice	1.91 - 0.002i
100	Water 20°C	3.505-2.007i
	Ice	1.88 - 0.00076i
150	Water 20°C	3.039-1.575j
	Ice	1.88 - 0.00076i
300	Water 20°C	2.587-0.937i
	Ice	1.88 - 0.00076i

lines. Dimer effects were also considered by Russian authors [85,86]. Gamble and Hodgens present data in Ref. 84 on the in band attenuation in dB/cm vs. visibility for a number of wavelengths between 320 mm to 8.57 mm and for atmospheric temperatures between 0° and 30°C in 5° C steps. A sample of their data is given here as Table XXXIX. Three figures of interest from Ref. 84 should be noted; data on the wavelength dependence of the refractive index of ice, presented here as Fig. 65; data giving the volume concentration of water droplets by size, presented here as Fig. 66, and the attenuation due to the liquid water content as a function of visibility for a number of wavelengths between 320 μm and 8.57 mm and a temperature of 24° C, presented here as Fig. 67. Gamble and Hodgens conclude that at any particular wavelength chosen in the mm band, water vapor absorption will be the driving unknown parameter. and will be a strong function of temperature and humidity. He feels that high resolution measurements need to be made to back up the actual calculations to be certain of the absolute attenuation at a given frequency.

3.3 Refractive Indices for Sea Spray

Eric Shettle[87] has reported on measurements of sea spray for wavelengths between 0.1 μm and 40.0 μm and a relative humidity of 80%. His data are presented here in Fig. 68. He also reported measured data on the refractive indices of water, sea spray aerosol and sea salt for wavelengths in the visible and infrared wavelength regions. There is a paucity of data on indices of refraction in the mm and sub mm wavelength ranges.

Table XXXIX. Total Attenuation (dB/km) For Water Vapor at 20° C (Data from Ref. 84)

V (m)	Wavelength											
	320 µm	345 µm	450 µm	490 µm	620 µm	650 µm	720 µm	880 µm	1.3 mm	2.3 mm	3.19 mm	8.57 mm
1000	190.80	95.46	85.91	108.52	95.41	66.81	30.59	19.13	4.81	1.55	0.76	0.25
900	190.82	95.48	85.93	108.54	95.43	66.82	30.60	19.14	4.82	1.55	0.76	0.25
800	190.85	95.51	85.95	108.56	95.44	66.84	30.61	19.16	4.83	1.56	0.77	0.25
700	190.89	95.55	85.99	108.60	95.47	66.86	30.64	19.18	4.84	1.56	0.77	0.25
600	190.95	95.61	86.04	108.65	95.51	66.90	30.68	19.21	4.86	1.57	0.79	0.25
500	191.05	95.70	86.12	108.72	95.57	66.96	30.73	19.25	4.89	1.58	0.79	0.25
400	191.19	95.84	86.24	108.84	95.66	67.04	30.81	19.32	4.93	1.60	0.81	0.26
300	191.47	96.11	86.48	109.06	95.83	67.21	30.98	19.46	5.02	1.64	0.83	0.26
200	192.19	96.81	87.09	109.64	96.28	67.64	31.40	19.81	5.24	1.75	0.89	0.27
100	195.11	99.66	89.57	111.97	98.11	69.39	33.12	21.23	6.13	2.16	1.15	0.30
90	195.91	100.44	90.25	112.61	98.61	69.87	33.59	21.62	6.38	2.28	1.22	0.31
80	196.95	101.45	91.14	113.44	99.25	70.50	34.20	22.13	6.70	2.42	1.31	0.32
70	198.39	102.86	92.36	114.60	100.13	71.33	35.05	22.83	7.14	2.63	1.44	0.33
60	200.47	104.83	94.10	116.23	101.43	72.53	36.24	23.83	7.77	2.92	1.61	0.35
50	203.57	107.93	96.80	118.72	103.41	74.48	38.11	25.37	8.74	3.37	1.89	0.39
40	208.87	113.13	101.30	123.02	106.73	77.63	41.21	27.96	10.38	4.12	2.36	0.44
30	219.07	123.03	109.90	131.15	113.13	83.73	47.21	32.87	13.50	5.58	3.25	0.55

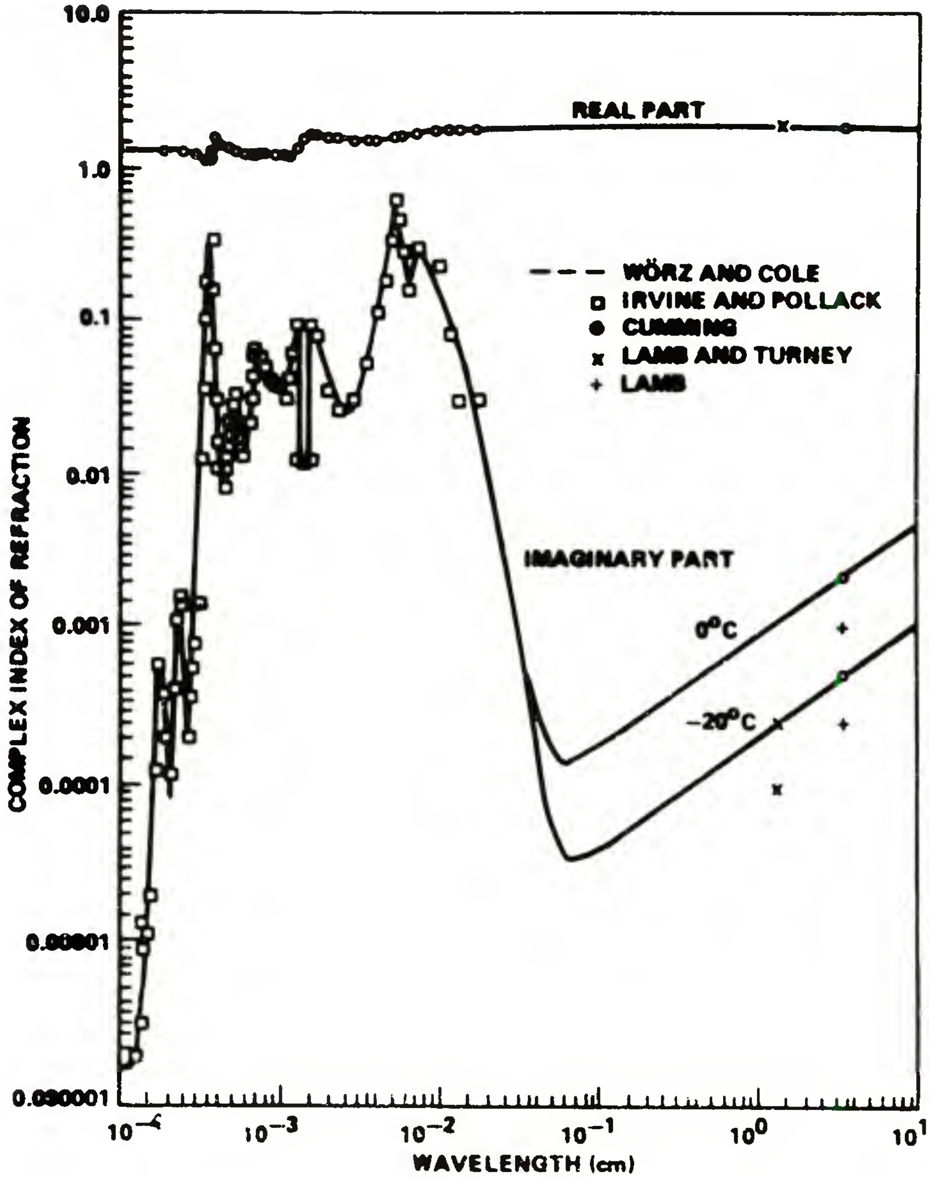


Fig. 65. Wavelength Dependence of the Real and Imaginary Parts of the Index of Refraction of Water (From Data in Ref. 84)

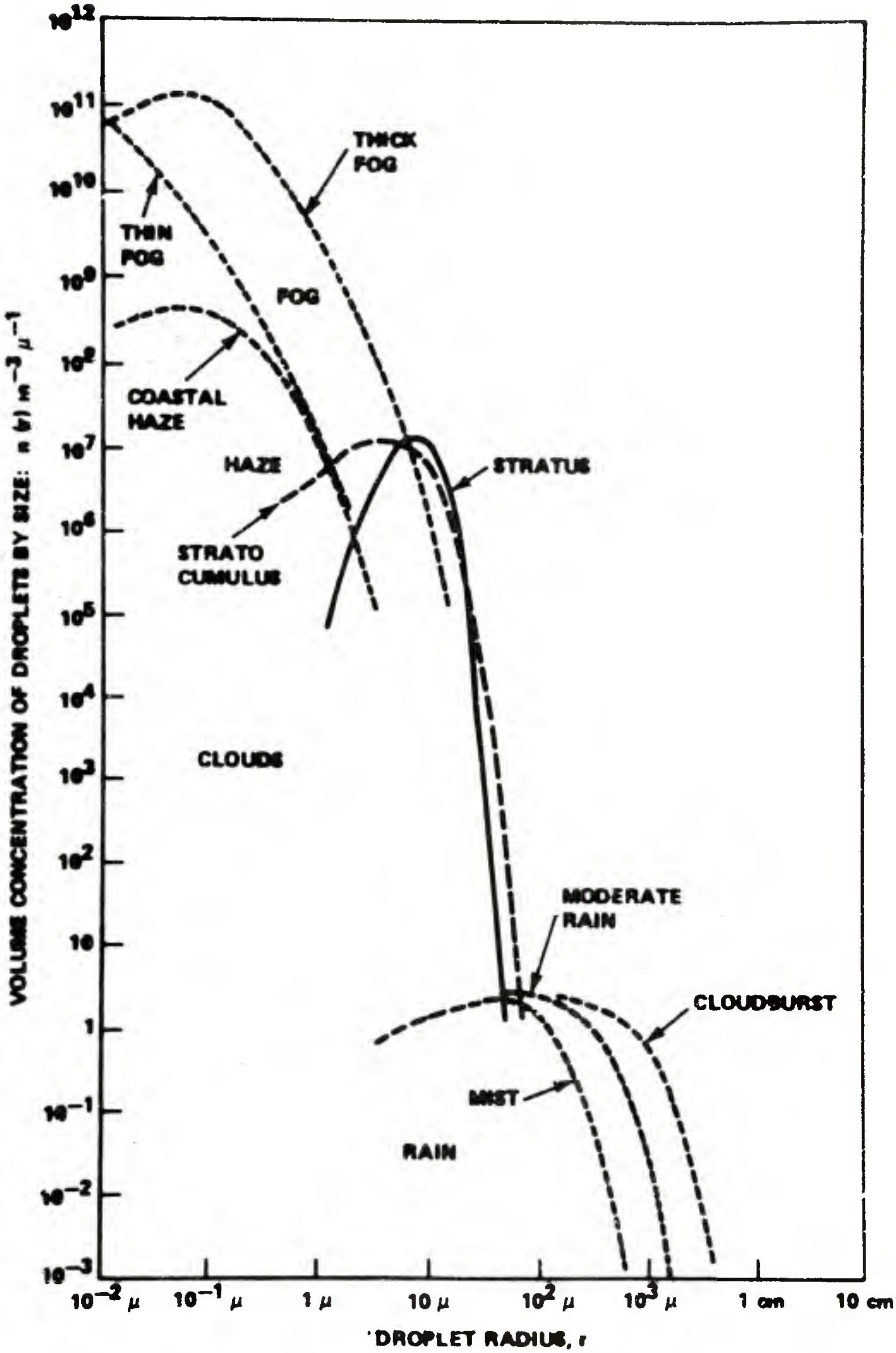


Fig. 66. Volume Concentration of Water Droplets by Size (Counted in 1-micron Intervals by Drop Radius.) (Data from Ref. 84)

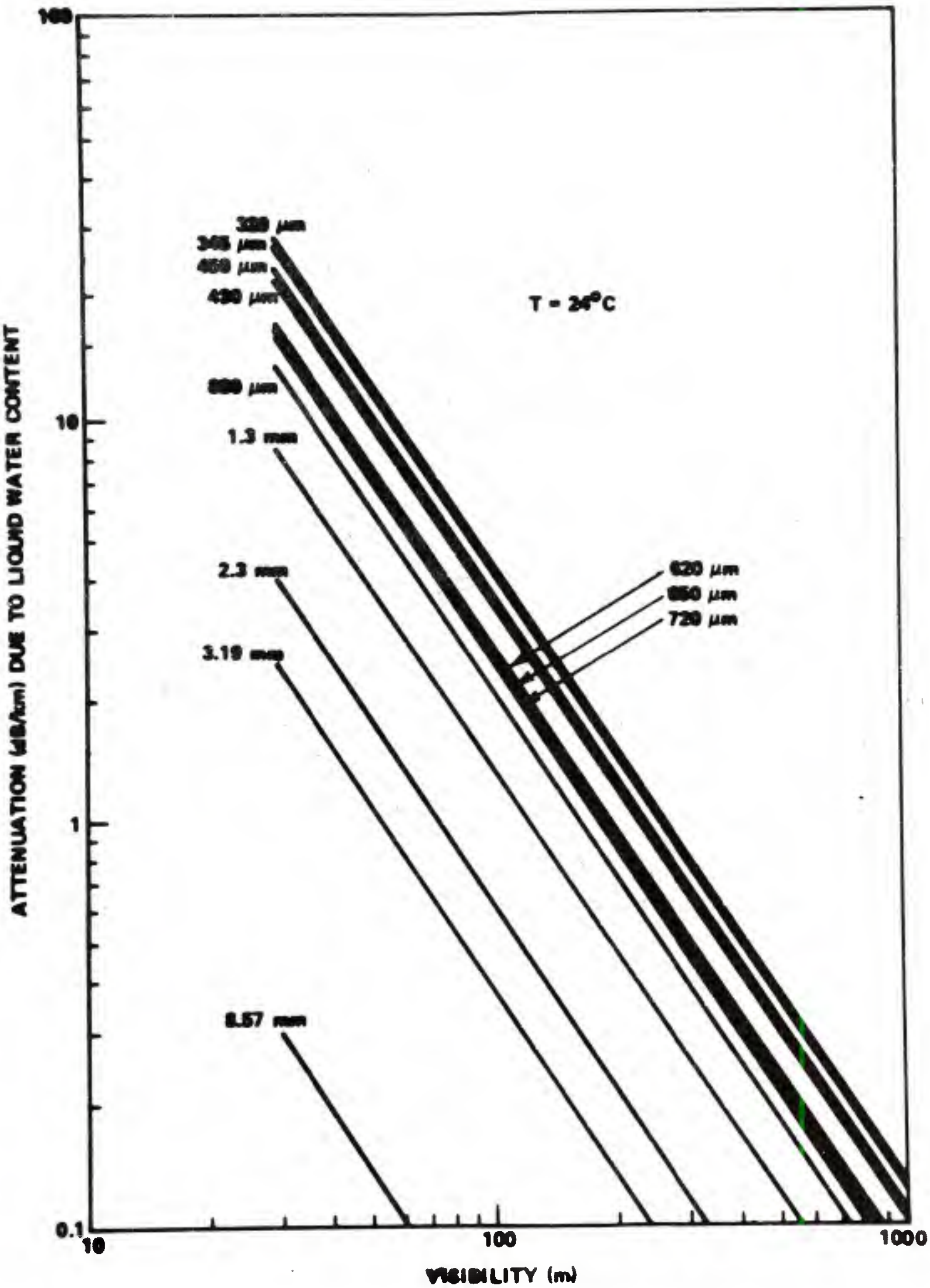


Fig. 67. Atmospheric Attenuation Due to Liquid Water Content Versus Visibility at a Temperature of 24°C and Wavelengths Between 320 μm and 8.57 mm (Data from Ref. 84)

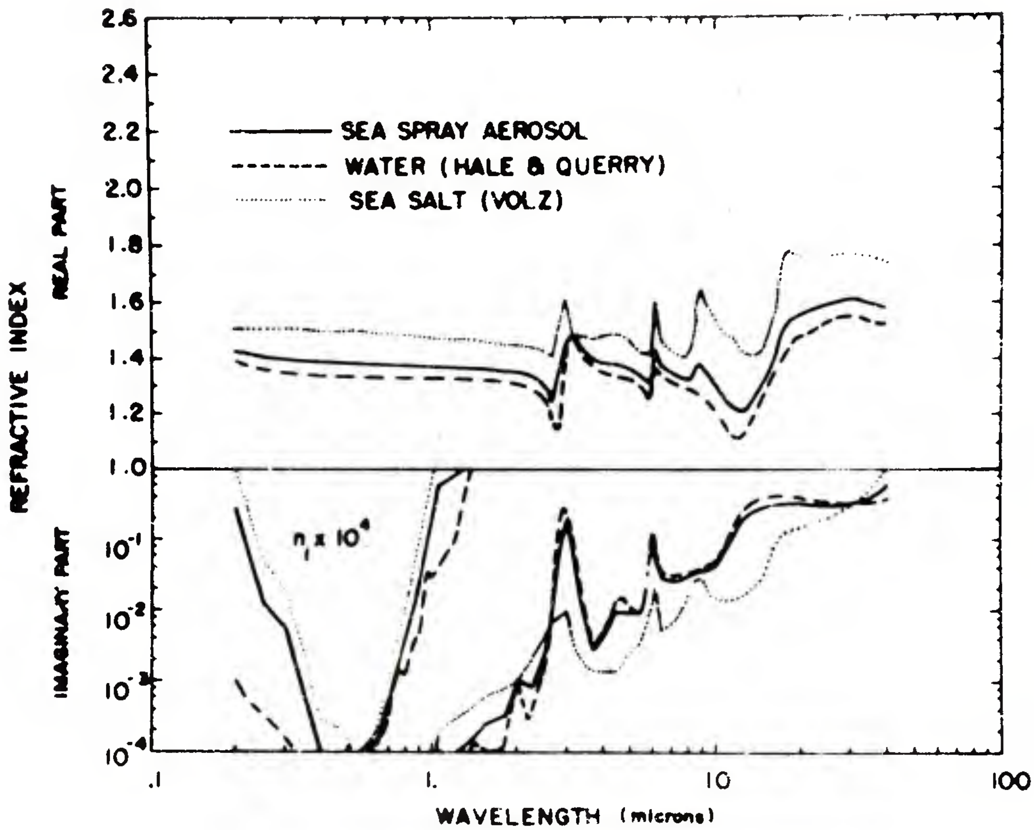


Fig. 68. Refractive Index of the Sea Spray Produced Aerosol at 80% Relative Humidity. Also shown are the Refractive Indices of Water and Sea Salt. (Data from Ref. 87)

IV. SUMMARY OF DOCUMENTS SURVEYED IN THE CLASSIFIED LITERATURE

A review of the classified literature showed that all the physical properties of the atmosphere and other media, e.g., rain, aerosols, snow, and battlefield conditions, were treated in the unclassified section. The classified documents were effectively hardware related and no new physical properties of the atmosphere were discussed.

V. RECOMMENDATIONS FOR FURTHER RESEARCH

Two of the most important attenuators of mm and sub mm radiation in the atmosphere are water vapor and oxygen. For the case of water vapor there are resonance frequency regions at approximately 1.3, 2.1, 3.2 and 8.6 mm where absorption is abnormally large. Much of the water vapor attenuation coefficient data currently available for the mm and sub mm wavelength range were measured or calculated over a decade ago. It appears that some new measurements would be useful for checking out the accuracy of band model calculations. The measurements need to consider the effects of temperature and pressure on the absorption cross section of water vapor. The Russians[86,87] have pointed out the importance of considering dimer effects, where attenuation is proportional to the square of the humidity, when calculating the absorption cross section for wavelengths in the 1.15 to 1.55 mm band. Most investigators have used a Lorentz line profile when calculating the contribution to the absorption cross section from the wings of each line. It appears that use of other line profiles, such as the Van Vleck-Weiskopf model, would probably produce more accurate water vapor absorption cross section data in the mm and sub mm wavelength range than that now available. The line broadening produced by (N_2 - H_2O), (O_2 - H_2O) and (H_2O - H_2O) collisions needs further investigation.

The absorption by oxygen in the mm and sub mm wavelength is usually considered to be fairly well known. Even so, the experimental and theoretical data now being used is over a decade old and a comparison of transmission calculations based on that data with measurements would be useful.

The index of refraction of liquid water at 20°C is fairly well known, but at other temperatures it is not well known. Thus, the transmission of mm and sub mm radiation through clouds and fogs containing

water droplets may be considered to be well known at 20° C but only at that temperature. A measurement program is needed to determine the temperature dependent parameters needed in the Debye equation.

There are a fair number of measurements of the attenuation and scattering coefficients for rain at frequencies of 15, 20, 30, 35 and 70 GHz, much fewer at frequencies of 94, 140, 240 and 300 GHz and none at frequencies above 320 GHz. The need to consider the effects of non-sphericity of rain drops, as suggested by Oguiche and discussed by Wiley[69], when computing scattering, absorption and extinction coefficients and phase function data with the use of Mie theory should be studied.

Propagation of mm and sub mm radiation through snow has not received much attention. At frequencies less than 50 GHz snow is not as important a scatterer as rain, but for frequencies greater than 150 GHz, and especially for wet snow, it will scatter more than rain. Calculations of the scattering and attenuation characteristics of snow with the use of Mie theory needs to consider the fact that snow flakes are not spheres. A measurement program is also needed to obtain more accurate values of the index of refraction for both ice and snow in the mm and sub mm wavelength range. Measurements of the index of refraction of ice and snow need to be made as a function of temperature and, for the case of snow, as a function of the "wetness" of the snow.

Aerosol effects have not been seriously considered for mm and sub mm wavelengths since for normal atmospheric aerosol size distributions the particle size is small enough for Rayleigh scattering theory to be applicable. Aerosol effects for battlefield type dust, which contains a significant fraction of large particles, needs further investigation. Studies need to be carried out on the scattering and absorption by large aerosol particles with a core of one material and an outside shell of another material. The index of refraction of aerosols for mm and sub mm

wavelengths needs to be measured so as to provide data to be used in Mie theory calculations.

There is no information available on the index of refraction for battlefield dusts, battlefield generated smokes and exotic gases and the aerosols produced by vehicle engines. Although some information on combustion products were found in the literature, there is a need for a study to define the specific combustion products emitted by the engines of battlefield vehicles and to determine which are important absorbers and scatterers of mm and sub mm wavelength radiation. Of great importance is the need for data on the size distributions of the particles contained in battlefield generated dusts and smoke.

Some data are available on the transmission of mm and sub mm radiation through battlefield generated dust and smoke (see Section 2.7). More effort needs to be expended to develop better models of the time and spatial dependent variation of battlefield smoke and dust particle size distribution. Since the particle sizes that are important in Mie theory calculations are those with diameters greater than 0.06 times the wavelength, the need to treat these large particles as nonspherical particles in Mie theory should be investigated.

The exotic gases produced under battlefield conditions should be identified and the absorption lines for these gases should be tabulated to determine which of the gases would be important absorbers for mm and sub mm wavelength radiation.

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83. Wolford Vogel, Scattering Intensity Plots and Transmission Coefficients for MM Wave Propagation Through Rain, University of Texas Electrical Engineering Labs., December 1971, AD 890 408L, Identifier No. 225381.

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86. A. A. Viktorova and S. A. Zhevakin, "Band Spectrum of a Water Vapor Dimer," Soviet Physics, Doklady, Vol. 15, No. 9, pp. 836-839, March 1971. Identifier No. 142181

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APPENDIX A - BIBLIOGRAPHY

A bibliography of the unclassified unlimited and limited literature on the interaction phenomena occurring in the atmosphere for millemeter and submillemeter radiation is given in the Appendix.

To aid the user of this bibliography, a 7-digit identifier or index number, on the same theme as the Dewey Decimal classification or key-word description, is given to each bibliographical entry. This 7-digit index number has the following form:

The first digit of the identifier number, which is used to identify the materials discussed in the biographical entry. is assigned numbers as follows:

1) Water vapor
2) Rain and aqueous water
3) Snow
4) Clouds and Fog
5) Air
6) Oxygen, O_2
7) Ozone
8) Nitrogen and its compounds (include Organic Compounds)
9) Exotic gases and Hydrocarbons
A) Smoke and Aerosols
B) Dust and Solid material
C) Hardware Discussions
D) Plasmas

The material identifiers listed above were selected to satisfy the terms of the work statement of the contract; additional identifiers are

provided because of titles specifically on these topics that had been reviewed and were considered useful peripheral information in mm wave technology. If an article discusses more than one material, and one of the materials discussed is one of those called out in the contract, then the article is listed under the material category called out in the contract. To identify the mm wave spectral region, the second digit of this 7 "digit" identifier is used in the following fashion:

1) 10-30 GHz (3.33 cm - 1 cm)
2) 30-100 GHz (1 cm - 3.33 mm)
3) 100-300 GHz (3.33 mm - 1 mm)
4) 300-1000 GHz (1mm - 333 μm)
5) 1000 GHZ - 3000 GHz (333 μm - 100 μm)
6) Greater than 3000 GHz (wavelength less than 100 μm)

For the third digit of the index number identifier, one of the following numbers for unclassified, unlimited distribution documents is used:

1) Experimental
2) Theory
3) Combination of Experimental and Theory

For limited distribution, unclassified documents, one of the following numbers for the third digit is used:

4) Experimental
5) Theory
6) Combination of Theory and Experimental

For confidential documents, the third digit was assigned as follows (to include the classification):

7) Experimental
8) Theory

9) Combination of Theory and Experimental

For secret classified documents, the third digit is assigned as follows:

A) Experimental

B) Theory

C) Combination of Theory and Experiment

To identify the specific technical area described in the bibliographical entry, such as transmission, reflection, etc., the fourth "digit" is used in the following way:

1) Transmission

2) Reflection

3) Cross Section

4) Backscatter

5) Dielectric

6) Index of Refraction

7) Emission

The fifth digit of the identifier number, which describes the project area described in the bibliographical entry, is assigned as follows:

1) Radar

2) Astronomy

3) Radiometry

4) Fourier Transform Spectrometer

5) Spectrometer and Michelson Interferometer

6) Remote Sensing

7) Communications

8) General Use

9) Obscurant

A) Laser and Maser

B) Missile Seeker

The sixth digit of the identifier number is used to indicate the number of articles in the bibliography on each title or technical area (1-9, A-Z). A computer code can be written to search on a file (tape or disc) where, with respect to an 80 column card, the first 7 columns would contain the 7 "digit" number. The last digit of the index number (the seventh) is used to designate the number of 80 column cards space in the file required to contain the subfile.

A.1 Illustration of Indexing/Identifier Technique

Let us pick a number and see how it refers to the indexing system discussed above (Along with discussion on what is on a file):

C 2 1 2 1 7 8 Author's name*title of article*contract number or where published (if not a government document)* (Example--Applied Optics, Vol. 10, No. 4, 738-748)

Date of Publication* and Government Publication Number such as AD-number*

Short Summary of article*(author's abstract used if it contains enough succinct information). The above information is packed to fit in as small a space as possible.

8 - 80 column card space used

7 th article of this type

Article is on Radar

Backscatter

Experimental Method, Unclassified

30 - 100 GHZ frequency range

Hardware Discussion

To allow a computer to access the contents of the index card file on a disc or a tape, the information given after the 7 digit identifier must be spaced by a computer recognizable identifier, e.g., an asterisk. The end of the abstract will end uniformly by a double asterisk for an end of file identifier for each article file.

A.2 UNCLASSIFIED BIBLIOGRAPHY

851781C*WALKER, R.E.: AND HOCHHEIMER, B.Z.*INVERSION-ROTATION EMISSION SPECTRUM OF THERMALLY-EXCITED NH3 IN THE 60-200 CM-1 REGION.*JOURNAL OF MOLECULAR SPECTROSCOPY 34,500-515.*1970* NO #.*THE INVERSION-ROTATION EMISSION SPECTRUM OF THERMALLY EXCITED NH3 IN THE 60-200 CM-1 REGION HAS BEEN MEASURED USING INTERFERENCE SPECTROSCOPY.INVERSION-ROTATION-FREQUENCY ASSIGNMENT,ASSOCIATED WITH THE V2,V4 AND 2V2 LOW LYING VIBRATIONAL LEVELS,ARE BASED EXTENSIVELY ON NEW I.R. ABSORPTION MEASUREMENTS.REFINEMENTS ARE MADE IN THE INVERSION-ROTATION MOLECULAR CONSTANTS FOR THE V2 VIBRATIONAL LEVEL, AND THE 2V2 INVERSION-ROTATION EMISSION SPECTRA IS EXTENDED.**

921761D*SAITO, SHUJI.*MICROWAVE SPECTRUM OF SULFUR DIOXIDE IN DOUBLY EXCITED VIBRATIONAL STATE AND DETERMINATION OF THE V CONSTANTS.*JOURNAL OF MOLECULAR SPECTROSCOPY 30,1-16.* 1969*NO #.*THE ROTATIONAL SPECTRA OF THE SULFUR DIOXIDE MOLECULE IN THE EXCITED STATES OF OVERTONES AND COMBINATION TONES,2V1,3V2,2V3,V1+V2,V2+V3,AND V1+V3 WERE OBSERVED.FROM THE ROTATIONAL CONSTANTS OF EACH STATE, _THE SECONDARY ORDER CHANGES OF THE ROTATIONAL CONSTANTS BY VIBRATIONS _,V11,V33, V12,V23,AND V13,AND THE THIRD ORDER CHANGE BY V2 VIBRATION, &222 WERE DETERMINED.THE DETERMINATION OF ALL THE VSS' CONSTANTS CONFIRMED THAT THE EXPANSION OF THE ROTATIONAL CONSTANTS IN TERMS OF THE VIBRATIONAL QUANTUM NUMBERS CONVERGES RATHER RAPIDLY FOR SO2.**

1411817*FLEMING, J.W.AND GIBSON, M.J.*FAR-INFRARED ABSORPTION SPECTRA OF WATER VAPOR H2(16)O AND INSOTOPIC MODIFICATIONS.* JOURNAL OF MOLECULAR SPECTROSCOPY 62,326-337.*1976*NO #.* FAR IR. ABSORPTION OF H2(16)O, H1(18)O, H2(16OD, D2(16)O, D2(18)O HAVE BEEN OBSERVED BETWEEN 10 AND 40 CM-1 OF A RESOLUTION OF 0.07 CM-1. EXPERIMENTAL AND CALCULATED LINE POSITIONS AGREE WITHIN THE ACCURACY OF THE EXPERIMENTS.**

851151F*BIRD, G.R.;HUNT, G.R.;GEBBIE, H.A.;AND STONE, N.W.B.* THE FAR-INFRARED PURE ROTATIONAL SPECTRUM OF NITROGEN DIOXIDE(NO2).*JOURNAL OF MOLECULAR SPECTROSCOPY 33,244-273.* 1970*NO #.*THE PURE ROTATIONAL SPECTRA OF NITROGEN DIOXIDE WAS MEASURED INTERFEROMATICALLY (WITH A MICHELSON INTERFEROMETER) FROM 45-104 CM-1,(.22MM-.096MM),WITH A RESOLUTION OF BETTER THAN .1 CM-1.MAGNETIC SPLITTING OBSERVED ON THE SPECTRUM AND ACCOUNTING FOR THIS WAS CRUCIAL TO THE ANALYSIS. THE SPECTRUM WAS ANALYZED IN TERMS OF MOMENTS OF INERTIA, MAGNETIC FINE STRUCTURE,AND CENTRIFUGS_AL DISTORTION. THE VALUES OF THE NECESSARY PARAMETER DETERMINED IN THE COMPLETE MICROWAVE ANALYSIS OF NO2 WERE USED TO COMPUTE A SPECTRUM IN EXCELLENT AGREEMENT WITH THE OBSERVED SPECTRUM. DETAILS OF THE CALCULATIONS AND VALUES OF THE PARAMETER INVOLVED ARE PROVIDED.**

B215418*BREEDER, K.H.AND SHEPPARD, A.P.*MM AND SUB MM DIELECTRIC MEASUREMENTS WITH AN INTERFACE SPECTROMETER.*NO NAME.*CONTRACT NONR-991(13)*17 NOV.1966*AD644523*AN INTERFERENCE TECHNIQUE USING A MICH_LSON INTERFEROMETER IS USED TO MEASURE THE DIELECTRIC CONSTANT AND LOSS TANGENT OF 4 MATERIALS)_(PYREX, TEFLON,REXOLITE,AND POLYSTYRENE) AT FREQUENCIES FROM 71-1000 GHZ. _THE EXPERIMENTAL SET UP IS DESCRIBED.AND THE DATA FOR THE 4 DIELECTRICS GIVEN.**

212171F*IPPOLITO, JR., LOUIS JOSEPH*SCATTERING IN DISCRETE RANDOM MEDIA WITH IMPLICATIONS TO PROPAGATION THROUGH RAIN.* NO #*MAY 1977*N77-27273*THIS IS A PHD DISSERTATION ON THE ABOVE TOPIC. THE ELECTOMAGNETIC SCATTERING WAVE EQUATION IS SOLVED VIA THE FOLDY TRANSFORMATION IN THE FIRST CHAPTERS,ITS DEFICIENCIES ARE NOTED.MULTIPLE SCATTERING IS THEN DISCUSSED VIA GREENS FUNCTIONS.SOME RESULTS ARE THAT THE FOLDY APPROXIMATION REPRESENTS THE COHERENT INTENSITY OF THE SCATTERED WAVE,BUT NOT THE INCOHERENT INTENSITY TERM. THE FOLDY APPROXIMATION TO THE MEAN FIELD IS THEN FOUND TO BE A USEFUL TECHNIQUE IN THE REPRESENTATION OF THE MEAN FIELD AND COHERENT INTENSITY BY CONSIDERING THE VOLUME SLAB OF DISCRETE SCATERERS AS A CONTINUOS RANDOM MEDIA WITH A _N EFFECTIVE PROPAGATION CONSTANT,BUT DOES NOT REPRESENT THE TOTAL INTENSITY.**

B511241B*PARKER, T.J.;LEDSHORN, D.A.;AND CHAMBERS, W.G.*DISPERSIVE REFLECTION SPECTROSCOPY IN THE FAR-INFRARED.*INFRARED PHYSICS VOL.16,293-297.*1976*NO #.*TECHNIQUES ARE DESCRIBED FOR MAKING DISPERSIVE REFLECTION MEASUREMENTS ON SOLIDS BETWEEN 5 AND 500 CM-1 AND AT TEMPERATURE ABOVE 77K USING FOURIER SPECTROMETERS WITH DIELECTRIC OR WIREGRID DIVIDERS AND USED IN THE ASYMMETRIC MODE.INTERFEROGRAMS CAN BE RECORDED WITH A POSITIONAL ACCURACY OF 0.1 UM,INDEPENDENT OF THE SPECIMEN TEMPERATURE.PERFORMANCE OF THE INSTRUMENTS IS ILLUSTRATED WITH AMPLITUDE REFLECTION MEASUREMENTS ON CRYSTALS OF NACL AND CSI AT ROOM TEMPERATURE.**

B51651C*HONIJK, D.D.;PASSCHIER, W.T.;MANDEL, M.;AND ASFAR, M.N.* THE DETERMINATION OF COMPLEX REFRACTIVE INDEX SPECTRA OF LIQUIDS IN THE FAR-INFRARED SPECTRAL REGION 5-500 CM-1, WITH DISPERSIVE FOURIER TRANSFORM SPECTROMETRY.*INFRARED PHYSICS VOL.16,257-262.*1976*NO #.*THE COMPLEX REFRACTIVE INDEX SPECTRUM OF TRANSPARENT AS WELL AS VERY ABSORBING LIQUIDS IS DETERMINED IN THE FAR-INFRARED SPECTRAL REGION 5-500 CM-1 FROM DISPERSIVE INTERFEROGRAMS OBTAINED WITH A VARIABLE THICKNESS VARIABLE TEMPERATURE CELL CONTAINING THE LIQUID SPECIMEN.THE COMPLEX REFRACTIVE INDEX OF THE WINDOW MATERIAL (SILICON,QUARTZ,_ CRYSTAL) IS DETERMINED WITH THE SAME SETUP FROM AN EMPTY CELL INTERFEROGRAM.**

B42581F*BORDEWIJK, P.*COMPARISON BETWEEN MACROSCOPIC AND MOLECULAR RELAXATION BEHAVIOUR FOR POLAR DIELECTRICS.*ADRIAN. MOLECULAR RELAXATION PROCESSES 5,285-300.*1973*NO #.* MICROSCOPIC AND MACROSCOPIC RELAXATION SPECTRA WERE COMPARED STARTING FROM THE DEPENDENCE OF THE MOLECULAR CORRELATION FUNCTION ON THE DIELECTRIC PERMITTIVITY DERIVED BY KLUG ET AL. IT APPEARS THAT A CORRESPONDING MICROSCOPIC DISTRIBUTION FUNCTION DOES NOT EXIST FOR EVERY MACROSCOPIC DISTRIBUTION OF RELAXATION TIMES,WHERE AS EVERY MACROSCOPIC DISTRIBUTION FUNCTION DOES CORRESPOND TO A MICROSCOPIC DISTRIBUTION FUNCTION. FOR A NUMBER OF CASES WHERE THE PERMITIVITY IS GIVEN AS A CLOSED FUNCTION OF THE FREQUENCY, MICROSCOPIC RELAXATION SPECTRA ARE CALCULATED.THE RESULTING MICROSCOPIC DISTRIBUTION OF RELAXATION TIMES ARE BROADER THAN THE CORRESPONDING MACROSCOPIC ONE.**

C31641E*AFSAR, M.N.;HASTED, J.B.;AND CHAMBERLAIN, J.* _NEW TECHNIQUES FOR DISPERSIVE FOURIER TRANSFORM SPECTROMETRY OF

LIQUIDS.*INFRARED PHYSICS VOL.16,301-310.*1976*NO #.*DISPERSIVE FOURIER TRANSFORM SPECTROSCOPY (DFTS) TECHNIQUES ARE DESCRIBED FOR MEASURING THE OPTICAL CONSTANTS OF LIQUIDS.FREE STANDING WIRE GRID POLARIZING AND MELINEX BEAM SPLITTERS ARE USED TO COVER A WIDE FREQUENCY RANGE AND LINK LOW AND HIGH FREQUENCY F.T.S DATA WITH MICROWAVE AND MID IR.DATA RESPECTIVELY. BOTH POWER ABSORPTION COEFFICIENT & AND REFRACTIVE INDEX N ARE COMPUTED AS CONTINUOUS FUNCTIONS FROM THE SAME DISPERSIVE MEASUREMENTS AND GOOD AGREEMENT HAS BEEN ACHIEVED WITH THE POWER ABSORPTION COEFFICIENT SPECTRUM OBTAINED USING CONVENTIONAL F.T.S.DATA IS PRESENTED FOR WATER,ALIPHATIC ALCOHOLS, HALOBENZENES AND HALOGEN-SUBSTITUTED METHANES.**

B215417*BREEDEN, K.H.; AND SHEPPARD, A.P.*MM AND SUB MM DIELECTRIC MEASUREMENTS WITH ANINTERFERENCE SPECTROMETER*NONR-991(13)* 17 NOV 1966*AD 644 523*AN INTERFERENCE TECHNIQUE UTILIZING A MICHELSON INTERFEROMETER TO MEASURE THE DIELECTRIC CONSTANT AND LOSS TANGENT OF 4 MATERIALS (PYREX, TEFLON, ROXOLITE AND POLYSTYRENE) AT FREQUENCIES FROM 71-1000 GHZ. THE EXPERIMENTAL SET UP IS DESCRIBED, AND DATA FOR THE 4 DIELECTRICS GIVEN.**

B512418*PARKER, T.J.; LEDSHORN, D.A.; CHAMBERS, W.G.*DISPERSIRIE REFLECTION SPECTROSCOPY IN THE FAR INFRARED*INFRARED PHYSICS, VOL. 16, 293-297,*1976*NO #*TECHNIQUES ARE DESCRIBED FOR MAKING DISPERSIVE REFLECTION MEASUREMENTS ON SOLIDS BETWEEN 5 AND 500 CM-1 AND AT TEMPERATURES ABOVE 77 DEGREES KELVIN USING FOURIER SPECTROMETERS WITH DIELECTRIC OR WIREGRID DIVIDERS AND USED IN THE ASYMMETRIC MODE. INTERFEROGRAMS CAN BE RECORDED WITH A POSITIONAL ACCURACY OF 0.1 UM, INDEPENDENT OF THE SPECIMENTS TEMPERATURE. PERFORMANCE OF THE INSTRUMENTS IS ILLUSTRATED WITH AMPLITUDE REFLECTION MEASUREMENTS ON CRYSTALS OF NACL AND CSI AT ROOM TEMPERATURE.**

1311717*BEAN, B.L. AND PERKOWITZ, S.*FAR INFRARED TRANSMISSION MEASUREMENTS WITH AN OPTICALLY PUMPED FIR LASER*APPLIED OPTICS VOL. 15, NO. 11, 2817-2818*NOV. 1976*USING A CO2 PUMPED FOR IR MEATHERED LASER AS A "TUNEABLE" OPTICAL SOURCE, THE ABSORPTION COEFFICIENT OF AQUEOUS WATER IN A QUARTZ WINDOWED CELL WAS MEASURED AT 4 FAR IR WAVELENGTHS - 96.5 UM, 263 UM, 232.9 UM, AND 570.5 UM.**

B12541H*BORDEWIJK, P. AND VAN GEMERT, M.J.C.*THE ANGLES OF INTERSECTION IN THE COLE-COLE PLOT IN RELATION TO THE ASYMPTOTIC BEHAVIOUR OF THE DISTRIBUTION FUNCTION OF RELAXATION TIME AND OF OTHER FUNCTIONS CHARACTERIZING DYNAMIC DIELECTRIC BEHAVIOR *ADVAN. MOL. RELAXATION PROCESSES, 4, 139-157*1972*IN THIS PAPER IT IS DEMONSTRATED TO BE POSSIBLE TO OBTAIN INFORMATION CONCERNING THE ASYMPTOTIC BEHAVIOR OF THE DISTRIBUTION FUNCTION OF RELAXATION TIMES STARTING ONLY FROM THE ANGLES OF INTERSECTION OF THE COLE-COLE PLOT WITH THE E' AXIS, WITHOUT AN EMPIRICAL FORMULA WHICH COVERS THE EXPERIMENTAL RESULT OVER THE WHOLE FREQUENCY RANGE. SIMILARLY, THE INFORMATION CONCERNING THE ASYMPTOTIC BEHAVIOR OF THE MEMORY FUNCTION, THE AFTER-EFFECT FUNCTION, THE CORRELATION FUNCTION, AND THE DISRIBUTION OF MOLECULAR RELAXATIONTIMES APPEARS TO BE OBTAINABLE. THE RELATIONSHIP DERIVED IN THIS WAY ARE USEFUL IF ONLY THE LOW FREQUENCY OR THE HIGH FREQUENCY SIDE OF THE DIELECTRIC DISPERSION CAN BE MEASURED.**

111174G*HENRY, P.*MEASUREMENTS AND FREQUENCY EXTRAPOLATION OF

MICROWAVE ATTENUATION STATISTICS ON THE EARTH-SPACE PATH AT 13, 19, AND 30 GHZ*IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION* 271-274*MARCH, 1975*THE PROGRAM TO USE THE CRAWFORD HILL SUN TRACKER FOR MEASUREMENT OF ATTENUATION ON THE EARTH-SPACED PATH AT 13,14, AND 30 GHZ IS DESCRIBED. CUMULATIVE STATISTICS FOR A YEAR OF LITERATURE PRESENTED, ALONG WITH A DISCUSSION OF LIKELY SOURCES OF ERROR. RESULTS ARE: 1) THE EXTRAPOLATION PROCEDURE BY HOGG, WHEREIN ATTENUATION MEASUREMENTS AT TWO FREQUENCIES ARE USED TO PREDICT ATTENUATION AT A THIRD YIELD RESULTS IN GOOD AGREEMENT WITH OBSERVATIONS EXCEPT AT VERY HIGH ATTENUATION LEVELS, 2) BECAUSE OF LIMITS ON THE MEASURING RANGE OF THE SUN TRACKER (RADIOMETER) MORE ACCURATE ESTIMATES OF FADING STATISTICS FOR FADES >30DB AT 30 GHZ CAN BE PROBABLY MADE BY EXTRAPOLATION THAN LONG DIRECT MEASUREMENTS.**

912541B*CHAMBERLAIN, J.; AFSAR, M.N.; DAVIES, G.J.; HASTED, J.B. AND ZAFAR, M.S.,*HIGH-FREQUENCY DIELECTRIC PROCESSES IN LIQUIDS*IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. MTT-22, NO. 12, 1028-1032*DEC. 1974* RECENT ADVANCES IN DISPERSIVE FOURIER TRANSFORM SPECTROMETRY ARE DESCRIBED. THE COMPLEX REFRACTIVE INDICES OF LOSSY MATERIALS ARE NOW DIRECTLY MEASURABLE OVER A WIDE SPECTRAL RANGE WHICH EXTENDS FROM MICROWAVE WAVELENGTHS TO THE MED. I.R. SOME RESULTS FOR ETHENOL AND BUTENOL ARE PRESENTED AND INTERPRETATION OF THE SPECTRA IN TERMS OF HYDROGEN BONDING IS OFFERED.**

9125429*CROSSLEY, J.*DIELECTRIC RELAXATION AND HYDROGEN BONDING IN LIQUID*ADVANCES IN MOLECULAR RELAXATION PROCESSES 2, 69-99* 1970*IN THE ARTICLE, DIELECTRIC ABSORPTION MEASUREMENTS ARE SHOWN TO BE A TOOL IN THE STUDY OF HYDROGEN BONDING IN LIQUID SYSTEMS. FIRST, THE CLASSICAL DEBYE THEORY IS GIVEN, THEN THE COLE-COLE SEMICIRCLE RELATIONSHIP IS DERIVED, OF E' VS E", THEN HYDROGEN BONDS IN WATER, WATER-DIOXENE MIXTURE, ALCOHOLS, PHENALS, ANITIRES, CHLOROFORM ARE DISCUSSED IN LIGHT OF DIELECTRIC RELAXATION TIMES.**

111171C*THOMPSON, M.C.; WOOD, L.E.; JONES, H.B.; AND SMITH, D.* PHASE AND AMPLITUDE SCINTILLATION IN THE 10 TO 40 GHZ BAND* IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. AP-23, NO. 6, 792-797*NOV. 1975*SIMULTANEOUS MEASUREMENTS OF PHASE AND AMPLITUDE VARIABILITY WERE MADE ON A 64 KM SLANT PATH USING 5 RADIO FREQUENCIES, 9.35, 14.4, 22.2, 25.4, AND 33.3 GHZ. THE 3 MIDDLE FREQUENCIES WERE CLOSEN FOR THEIR RELATION TO WATER VAPOR ABSORPTION. THE AMPLITUDE DATA SHOW OCCASIONAL FADES IN EXCESS OF 20 DB SUPERIMPOSED ON SMALL OR SCINTILLATIONS OF SEVERALDB. NEITHER PHASE NOR AMPLITUDE VARIABILITY SHOW EFFECTS ON THE MOLECULAR RESONANCE OF WATER VAPOR AT 22.2 GHZ.**

212171C*GOLDHIRSH, JULIUS*PREDICTION METHODS FOR RAIN ATTENUATION STATISTICS AT VARIABLE PATH ANGLES AND CARRIER FREQENCIES BETWEEN 13 AND 100 GHZ*IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. AP-23, NO. 6, 786-791*NOV. 1975*FADE DEPTH AND SPACE DEVERSITY STATISTICS OF PROPAGATION ALONGE EARTH-SPACE PATHS HAVE BEEN CALCULATED FROM RADAR REFLECTIVITY DATA OF RAINS USING MODELING TECHNIQUES. THE REFLECTIVITY DATA BASE WAS OBTAINED DURING THE SUMMER OF 1973 AT WALLOPS

ISLAND, VA. USING A HIGH RESOLUTION S-BAND RADAR INTERFACED WITH A COMPUTER AND DIGITAL PROCESSING SYSTEM. FADE STATISTICS HAVE BEEN CALCULATED FOR VARIOUS PATH ANGLES AND SEVERAL FREQUENCIES BETWEEN 13 AND 100GHZ.**

2211718*SANDER, JOERG*RAIN ATTENUATION OF MILLIMETER WAVES LAMBDA = 5.77, 3.3, AND 2 MM*IEEE TRANSACTIONS ON ANTENNA AND PROPAGATION _, VOL. AP-23, NO. 2, 213-220*MARCH _, 1975* MEASUREMENTS OF RAINFALL ATTENUATION OF MM WAVES AT 5.77, 3.3, AND 2 MM WAVELENGTH WERE CONDUCTED DURING 1969-1970. SIMULTANEOUSLY RECORDED METEOROLOGICAL QUANTITIES WERE THE TION COEFFICIENTS AS A FUNCTION OF RAINFALL RATE WERE THUS DETERMINED.

522161B*SHEN, LIANG-CHI*REMOTE PROBING OF ATMOSPHERE AND WIND VELOCITY BY MILLIMETER WAVES*IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. AP-18, NO. 4, 493-497*JULY 1970* A TECHNIQUE IS DEVELOPED TO PROBE THE ATMOSPHERE TURBULENCE STRENGTH CN2 AND THE WIND VELOCITY ALONG A PATH USING MM WAVES AS A TOOL. DATA OBTAINED IN A LINE-OF-SIGHT MM WAVE PROPAGATION EXPERIMENT ARE PROCESSED AND USED AS THE SOURCE OF INFORMATION. THE AVERAGE CN2 AND WIND VELOCITY - TOGETHER WITH THEIR GRADIENTS ALONG THE PROPAGATION PATH ARE CALCULATED BY CONVERTING A SET OF INTEGRAL EQUATIONS. A NUMERICAL METHOD IS USED TO YIELD THE LEAST SQUARE ERROR SOLUTIONS.**

262121D*SOKOLORE, A.V.*ATTENUATION OF VISIBLE AND INFRARED RADIATION IN RAIN AND SNOW*RADIO ENGINEERING AND ELECTRONIC PHYSICS, VOL. 15, NO. 12*,2175-2178*1970*THE RESULTS OF A THEORETICAL CALCULATION OF RAIN ATTENUATION IN THE RANGE OF 0.63-100 UM, OBTAINED FROM RIGOROUS FORMULAS OF MIE'S DIFFRACTIONS THEORY, ARE PRESENTED FOR THE CASE WHERE THE REFRACTIVCE INDEX OF RAIN DROPS CORRESPONDS TO THE DATA OF ZENTANO, AND THE DROP SIZE DISTRIBUTION IS IN ACCORDANCE WITH THE RESULTS OF BEST, POLYKOVA. IT IS SHOWN THAT THE THEORETICAL RESULTS OF ATTENUATION ARE GOOD FROM 6.3 UM TO 3.5 UM. A COMPARISON OF THE RESULTS OF ATTENUATION IN SNOW AT WAVELENGTHS OF .6329 AND 10.6 MM #2 OVER 1.36 KM PATH AS PRESENTED.**

223171C*DUDZENSKY, ZR., S.J.*ATMOSPHERIC AFFECTS ON TERRESTRIAL MM WAVE COMMUNICATIONS*CONTRACT DAHC15-73-C-0181*MARCH 1974* AD 780 602*A METHODOLOGY FOR QUANTITATIVELY ESTIMATING THE PERFORMANCE OF MM WAVE SYSTEM (30-300GHZ) IN THE ATMOSPHERE AND IN THE PRESENCE OF RAINFALL. INFORMATION ON THE TRANSMISSION PROPERTIES OF MM WAVES IS COMBINED WITH CURRENTLY AVAILABLE METEOROLOGICAL DATA TO DERIVE THE METHODOLOGY. THE AVAILABLE PROPAGATION AND RAINFALL DATA FOR A GIVEN CLIMATIC REGION ARE USED TO DERIVE CURVES GIVING ATTENUATION DUE TO RAINFALL VS PATHLENGTH FOR VARIOUS FREQUENCIES. EMPHASIS IS ON HIGH RELIABILITY COMMUNICATIONS IN WHICH OUTAGES ARE 0.1% OR LESS.**

C23171A*COFFIN, WM. E.*MISSION ANALYSIS ON COMMAND AND CONTROL COMMUNICATION FOR THEATER OPERATIONS (MM RADIO TRANSMISSION FOR INTRA BASE COMMUNICATIONS*CONTRACT NO.F19628-71-C-0210* 15 JULY 1971*AD 901 371*THIS IS A PRACTICAL DISCUSSION OF MM WAVES IN A MILITARY BASE FOR LOCAL COMMUNICATIONS, NETWORKS, COSTS VS 4 WIRE BURIED TELEPHONE CABLE: IT HAS SOME UNPUBLISHED DATA OF DE BETTENCOURT ON ATTENUATION OF MM

WAVES IN RAIN IN THE 30-95 GHZ BAND. IT APPEARS THAT MM WAVES MAY BE A BETTER SOLUTION THAN ORDINARY 4-WIRE CABLE FOR SEVERAL REASONS.**

622131C*GREENEBAUM, M.*THE CALCULATION OF MM AND SUB MM WAVE ABSORPTION LINE PARAMETERS FOR THE MOLECULAR OXYGEN ISOTOPES: (16)02, (16)0(18)0, AND (18)02. *CONTRACT NO. DAAH01-74-C-0419*15 AUG 1975*AD A017 397*CALCULATIONS (USING APL LANGUAGE) ARE DESCRIBED WHICH YIELD ABSORPTION LINE PARAMETERS FOR THE 3 MENTIONED 02 ISOTOPES; IN THE FORMAT OF THE AFCRL ATMOSPHERIC LINE PARAMETERS COMPILATION. THE LINE PARAMETERS ARE LINE WIDTH, LOWER STATE ENERGY, AND IDENTIFYING QUANTUM NUMBERS. THESE PARAMETERS ARE REQUIRED AS INPUT TO THE SLAM PROGRAM (DESCRIBED ELSEWHERE) WHICH CALCULATES THE ATTENUATION VS ALTITUDE IN ANY FIXED FREQUENCY IN THE MM-SUB MM WAVE REGION.**

7211319*SILVER, SAMUEL*SOLAR RADIATION AND ATMOSPHERIC ABSORPTION IN THE MM WAVE REGION (SEMIANNUAL PROGRESS REPORT) *CONTRACT ONR-NOVR 222(54), AND NSG 243*AUG 25, 1967*AD 656 734*
1) ABSORPTION OF OZONE AND O2 WERE STUDIED AT 36 AND 37 GHZ IN A 5' LONG ABSORPTION CELL, AT A PRESSURE OF 40 MM HG.
2) EMISSION FROM H20 WAS STUDIED WITH A RADIOMETER OF 13,000 FT ALTITUDFE - SKY BRIGHTNESS - WITH A RADIOMETER OF 1.5 AND .8 CM.
3) OBSERVATIONS OF JUPITER, VENUS, AND TAURUS A WERE MADE AT 1.35 CM WITH A 10' ANTENNA - AND A RADIOMETER.**

943141 *EVANS, G.J. AND EVANS MYRON*AN EXPERIMENTAL STUDY AND CLASSICAL TREATMENT OF THE FAR INFRA-RED INDUCED DIPOLAR ABSORPTION IN GASEOUS ETHYLENE*ADVAN. MOL. RELAXATION PROCESSES 9, 87-103*1976*NO #*THE FAR I.R. ABSORPTION SPECTRUM OF THE COMPRESSED GAS ETHELENE HAS BEEN MEASURED IN THE REGION 10-200 CM-1 AT PRESSURES FROM 14.7-55.76 AT 296 DEGREES KELVIN. THE ORIGIN OF THE BROAD BANDS OBSERVED IS A BR MOLECULAR COLLISION INDUCED ABSORPTION AS SHOWN BY THE DEPENDENCE OF THE TOTAL INTEGRATED INTENSITY ON THE SQUARE OF THE MOLECULAR NUMBER DENSITY.**

B61681B*GRAMS, G.W.; BLIFFORD,JR., I.H.;GILLETTE, D.A.; AND RUSSELL, D.B.*COMPLEX INDEX OF REFRACTION OF AIRBORNE SOIL PARTICLES*JOURNAL OF APPLIED METEOROLOGY, VOL. 13, 459-471= JUNE 1974*NO #*THE ANGULAR VARIATION OF THE INTENSITY OF LIGHT SCATTERED FROM A COLLIMATED BEAM BY AIRBORNE SOIL PARTICLES AND THE SIZE DISTRIBUTION OF THE PARTICLES WERE MEASURED SIMULTANEOUSLY 1.5 M ABOVE THE GROUND. THESE MEASUREMENTS GAVE AN ESTIMATE OF THE COMPLEX INDEX OF REFRACTION M = NVR - NIMI OF AIRBORNE SOIL PARTICLES. NRE WAS DETERMINED BY STARLANDQR MICROSCORES TECHNIQUES TABS 1.525 (LAMBDA = .488U). THE UPPER BOUND FOR NIM WAS DETERMINED TO BE .005.**

A614619*RUSSELL, PHILIP B. AND HAKE, JR., RICHARD D.*THE POST-FUEGO STRATOSPHERIC AEROSOL: LIDAR MEASUREMENTS, WITH RADIATIVE AND THERMAL IMPLICATIONS*JOURNAL OF THE ATMOSPHERIC SCIENCES, VOL. 34, 163-177*1977*THIS REPORT IS LIDAR MEASURE-MENTS OF STRATOSPHERIC AEROSOLS, BETWEEN FEBRUARY AND NOVEMBER 1975, OF PARTICULATE BACKSCATTERING FOLLOWING THE ERUPTION OF THE VOLCANO FUEGO ON OCTOBER 1974. THE PEAK SCATTERING RATIO OF THE 1975 PROFILE WAS 1.7, AND THE VERTICALLY INTEGRATED PARTICULATE BACKSCATTERING WAS 3.6X10-4 SR-1 AT .694 UM.**

A63181D*ACKERMAN, T.P.*A MODEL OF THE EFFECT OF AEROSOLS ON

URBAN CLIMATES WITH PARTICULAR APPLICATIONS TO THE LOS ANGELES BASIN*JOURNAL OF THE ATMOSPHERIC SCIENCES, VOL. 34, 531-547*MARCH 1977*NO #*A 1-DIMENSIONAL, TIME DEPENDENT MODEL OF THE BOUNDARY LAYER HAS BEEN DEVELOPED TO STUDY THE EFFECT OF POLLUTANTS ON LOCAL METEOROLOGICAL VARIABLES. RADIATIVE TERMS FOR THEMODEL ARE COMPUTED USING A 4-STREAM DISCRETE ORDINATE METHOD, CONVECTION TERMS ARE PARAMETERIZED AT THE SURFACE USING TRANSFER COEFFICIENTS AND DYNAMICAL TERMS ARE PARAMETERIZED FROM AVAILABLE DATA. THE MODEL IS COMPARED METRICALLY FOR THE GREAT PLANE DATA WITH GOOD RESULTS. OPTICAL-IR BANDS ARE FROM THE UV AT .347 UM, THE WATER VAPOR LINE AT 330 CM-1.**

A13561A*BORDIN, L.F.; KIRDYASKORI, K.P.; STAHANKIM, YU. P., AND CHUKHLANTSEV, A.A.*ON THE APPLICATION OF MICROWAVE RADIOMETRY TO FOREST FIRE SURVEYS*RADIO ENGINEERING AND ELECTRONICS PHYSICS 21, 89-91*SEPT 1976*NO #*THE INTENSITY OF THE FLAME RADIATION OF A FOREST FIRE OF MICROWAVE FREQUENCIES IS ESTIMATED. THE EFFECT OF THE SMOKE PLUME AND THE TREE TOPS ON THE MICROWAVE RADIATION SPECTRUM AND THE POSSIBILITY OF DETECTING FOREST FIRES SOUCES USING AIRBORNE MM WAVE RADIOMETERS IN THE .8 AND 3.4 CM WAVELENGHT BANDS. THE .8 MM BAND DEFINITELY SHOWS THE FIRE AREA BETTER THAN THE 3.4 MM BAND RADIOMETER.**

C115817*HODI, M.A.; HUNTER, W.N.; NORTH, A.M.; PETHRICK, R.A.; AND TOWLAND, M.*METHODS AVAILABLE FOR THE MEASUREMENT OF DIELECTRIC RELAXATION IN THE MEGA - GIGAHERTZ FREQENCY RANGES* ADVAN. MOL. RELAXATION PROCESSES 6, 267-286*1975*NO #*THIS ARTICLE REVIEWS VARIOUS METHODS OF MEASURING DIELECTRIC PHENOMENA IN SOLIDS, LIQUIDS AND GASES IN THE 100 MHZ - 3X1013 HZ FREQUENCY RANGE,AND METHODS OF DATA REDUCTION.**

8135619*EVANS, MYRON AND DAVIES, GRAHAM J.*A SIMPLE MODEL FOR THE ORIENTATIONAL CORRELATION FUNCTIONS OF DIPOLAR AND INDUCED-DIPOLAR ABSORPTION IN LIQUIDS*ADVAN. MOL. RELAXATION PROCESSES _, VOL. 9, 129-152*1976*THIS PAPER'S PURPOSE IS TO PRESENT A COHERENT STATISTICAL ACCOUNT OF THE ROTARY DYNAMICS OF DIPOLAR AND NON-DIPOLAR MOLECULES IN THE LIQUID STATE IN TERMS OF THEIR RESPECTIVE ORIENTATIONAL CORRELATION FUNCTIONS THESE ARE RELATED TO THE BROAD MICROWAVE AND FOR I.R. ABSORPTION BANDS OF THE LIQUID PHASE FROM .1 CM-1 (3 GHZ) TO 500 CM-1.**

2125718*NO AUTHOR GIVEN*EQUATIONS FOR CALCULATING THE DIELECTRIC CONSTANT OF SALINE WATER*IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, 733-736*AUG 1971*NO #*THE DIELECTRIC CONSTANT OF SALINE WATER MAY BE REPRESENTED BY AN EQUATION OF THE DEBYE FORM EQUATIONS FOR THE PARAMETERRS IN THE DEBYE EXPRESSION ARE GIVEN AS FUNCTIONS OF WATER TEMPERATURE AND SALINITY. BOTH THE REAL AND IMAGINARY PARTS ARE GIVEN, FOR 3.25, 9.14, 23.7 AND 48.6 GHZ RADIATION.**

141151A*BECKMAN, J.E. AND HARRIES, J.E.*SUBMILLIMETER-WAVE ATMOSPHERIC AND ASTROPHYSICAL SPECTROSCOPY*APPLIED OPTICS, VOL. 14, _ NO. 2, 470-485*FEB 1975*NO #*THIS IS A REVIEW ARTICLE ON WORK DONE AT THE U.K. NATIONAL PHYS. LAB. AND QUEEN MARY COLLEGE ON THE SUB MM SPECTRUM AND ITS APPLICATION TO ATMOSPHERIC AND ASTROPHYSICAL PROBLEMS. A NPL-GRUBB PARSONS TYPE OF MICHELSON INTERFEROMETER IS USED IN AIRCRAFT FLYING AT 12 KM AND ABOVE, TO RECORD THE SUB MM EMISSION OF THE STRATOSPHERE IN THE 15 CM-1 RANGE OF H2O, O3, HNO3,

AND OTHER GASES.**
B125829*TJIA, T.H.; BORDEOIJK, P.; AND BOTTCHER, C.J.F.*ON THE NOTION OF DIELECTRIC FRICTION IN THE THEORY OF DIELECTRIC RELAXATION*ADVAN. IN MOLECULAR RELAXATION PROCESSES, VOL. 6, 19-28* 1974*NO #*IN THIS PAPER, NEE AND ZWANZIG'S CONCEPT OF DIELECTRIC FRICTION IS ANALYZED AND SHOWN THAT THEIR DERIVATION IS INCONSISTENT. THE INFLUENCE OF DIPOLE-DIPOLE INTERACTION ON DIELECTRIC RELAXATION IS THEN INVESTIGATED IN ANOTHER WAY WHICH SHOWS THAT THIS INTERACTION INDEED LEADS TO AN INCREASE INTHE DIELECTRIC RELAXATION TIME.**
B125818*CROSSLEY, J.; TAY, S.P.; AND WALKER, S.*EVALUATION OF RELAXATION PARAMETERS ACCORDING TO BUDO' EQUATIONS*ADVAN. IN MOLECULAR RELAXATION PROCESSES, 79-83*1974*NO #*EXPERIMENTAL DATA ON DIELECTRIC CONSTANT AND LOSS FACTORS ARE ANALYZED VIA BUDO'S EQUATIONS, WHICH RELATE THE REAL AND IMAGINARY PARTS OF THE DIELECTRIC CONSTANT TO LINEAR SUPERPOSITIONS OF TWO DIELECTRIC (LORENTZIAN) AND TWO LOSS TERMS, EACH WITH DIFFERENT RELAXATION TIMES AND TWO WEIGHT CONSTANTS. THE DIELECTRIC DATA FOR 14 MIXTURES, EACH CONTAINING 2 POLAR SOLUTES AND A NON-POLAR SOLVENT WERE ANALYZED.**
D323661E*LAX, B. AND COHN, D.R.*INTERACTION OF INTENSE SUBMILLIMETER RADIATION WITH PLASMA*IEEE TRANSACTION ON MICROWAVE THEORY AND TECHNIQUES, VOL. MTT-22, NO. 12, 1049-1052*DEC 1974*NO #*RECENT ADVANCES IN THE DEVELOPMENT OF HIGH POWER SUB MM LASERS HAVE OPENED UP NEW AREAS OF INVESTIGATION IN THE STUDY OF LASER PLASMA INTERACTION. THESE AREAS INCLUDE STUDIES OF LASER-INDUCED GAS BREAKDOWN AND PLASMA HEATING AT CYCLOTRON RESONANCE, LASER-INDUCED BREAKDOWN EFFECTS IN SOLIDS, AND STUDIES OF LASER-GENERATED PARAMETRIC INSTABILITIES IN ARC PLASMAS. IN ADDITION, THESE SUB MM LASERS CAN BE USED FOR DIAGNOSTIC MEASUREMENTS IN TOKAMAK PLASMAS, WHICH INCLUDE ION TEMPERATURE MEASURE-MENTS BY THOMSON SCATTERING,AND OF TRANSVERSE THERMAL CONDUCTIVITY.**
D31661F*WOLFE, S.M.; BUTTON, K.J.; WALDMAN, J.; AND COHN, D.R.* MODULATED SUBMILLIMETER LASER INTERFEROMETER SYSTEM FOR PLASMA DENSITY MEASUREMENTS*APPLIED OPTICS, VOL. 15, NO. 11, 2645-2648*NOV. 1976*NO #*A HIGH RESOLUTION SUBMILLIMETER INTERFERO _METER SYSTEM FOR MEASUREMENT OF ELECTRON DENSITIES IN THE 1.E14 CM-3 < NE < 2.E15 CM-3 RANGE HAS BEEN DEVELOPED FOR USE IN HIGH DENSITY TOKOMAKS. PHASE MODULATION AT 1 MHZ IS ACCOMPLISHED BY DIFFERENCE FREQUENCY MIXING OF TWO CAVITY TUNED CO2 LASER OSCILLATORS. THE OPTICALLY PUMPED CH3OH LASERS, WHICH OPERATE AT 118.8 UM, FEATURE A NOVEL OUTPUT COUPLING DESIGN THAT PERMITS GOOD MODE QUALITY AND LOW BEAM DIVERGENCE. THE BEST SIGNALS ARE DETECTED USING A NEWLY DEVELOPED GE LI PHOTOCONDUCTOR, AND A DIRECT MEASUREMENT OF THE PHASE SHIFT FROM THE TIME LAG BETWEEN PROBE AND REFERENCE SIGNALS.**
S21621A*DAVIS, JOHN H. AND COGDELL, JOHN R.*ASTRONOMICAL REFRACTION AT MILLIMETER WAVELENGTHS*IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. AP-18, NO. 4, 490-493*JULY 1970*NO #*MEASUREMENTS OF THE DIFFERENCE BETWEEN RADIO AND OPTICAL ASTRONOMICAL REFRCTION AT LAMBDA - 8.6, 4.3, 3.1, AND

2.2 MM ARE DESCRIBED. THE MEASUREMENT TECHNIQUES UTILIZED SOLAR LIMB CROSSING TIMES OBSERVED WITH A 16-FT RADIO TELESCOPE. RESULTS SHOW THE EXPECTED DEPENDENCE UPON ATMOSPHERIC WATER VAPOR BELOW LAMBDA = 3 MM, BUT RADIO REFRACTION TENDS TO APPROACH OPTICAL REFRACTION AT THE SHORTEST WAVELENGTH.**

421181E*LO, LAI-TUN; FANNIN, BOB M.; AND STRAITON, ARCHIE W.* ATTENUATION OF 8.6 AND 3.2 MM RADIO WAVES BY CLOUDS*IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. AP-23, NO. 6, 782-786* NOV 1975*NO #*MEASURED ATTENUATIONS ASSOCIATED WITH A VARIETY OF CLOUD CONDITIONS AT WAVELENGTHS NEAR 8.6 AND 3.2 MM ARE REPORTED. TWO SPECIFIC EVENTS, DURING WHICH HEAVY RAIN CLOUDS COVERED THE SKY, ARE EXAMINED AND STATISTICAL DATA COLLECTED OVER A 6-MONTH PERIOD ON A VARIETY OF CLOUD TIONS WERE THE RAIN BEARING CUMULONIMBUS AREA. OF THE NON-RAIN CLOUDS, THE TWO TYPES FOR WHICH THE SAMPLE SIZES ARE ADEQUATE AND ATTENUATIONS ARE SUFFICIENT FOR MEANINGFUL CONCLUSIONS ARE STRATO CUMULUS AND CUMULUS, THEIR 35 GHZ/ 95 GHZ MEAN ATTENUATIONS BEING 0.18/0.61 DB AND 0.12/0.34 DBM, RESPECTIVELY.**

343111 *BABKIN, YU.S.; SEKHAKOV, I.A.; SOKOLOV, A.V.; STROGANOV, L.I.; AND SUKHONIN, YE.V.*ATTENUATION OF RADIATION AT A WAVE LENGTH OF 0.96 MM IN SNOW*RADIO ENGINEERING AND ELECTRONIC PHYSICS, VOL. 15, NO. 12, 2171-2174*1970*NO #*THE ATTENUATION OF RADIATION ON SNOWFALLS WITH RATE UP TO 2 MM/HR, COMPARED TO ATTENUATION OF MELTED WATER, IS MEASURED AT A WAVELENGTH OF 0.96 MM OVER A 680 M PATH. IT IS SHOWN THAT THE ATTENUATION IN RAINFALLS WITH THE SAME INTENSITY IS LOWER BY 3.0-40%. A HIGHLY IDEALIZED COMPUTATION OF THE ATTENUATION IN SNOWFALL IS CARRIED OUT ON THE BASIS OF MIE'S THEORY: THE COMPUTATIONS AGREE WITH THE EXPERIMENTAL DATA IF ONE INTRODUCES EFFECTIVE RADII OF SPHERICAL SNOW PARTICLES.**

1411416*FLEMING, J.W.*HIGH-RESOLUTION SUBMILLIMETER-WAVE FOURIER-TRANSFORM SPECTROMETRY OF GASES*IEEE TRANSACTIONS ON MICRO-WAVE THEORY AND TECHNIQUES, VOL. MTT-22, NO. 12, 1023-1025*DEC 1974* NO #*THIS PAPER DESCRIBES NEW SPECTRA OF H20, N20, AND SO2 IN THE 10-40 CM-1 (1 MM - .25 MM) REGION, AT A RESOLUTION OF 0.05 CM-1.**

623171C*REBER, EARL E.; MITCHELL, RICHARD L.; AND CARTER, CLARENCE J.; ATTENUATION OF THE 5-MM WAVELENGTH BAND IN A VARIABLE ATMOSPHERE*IEEE TRANSACTION ON ANTENNAS AND PROPAGATION VOL. AP-18, NO. 4, 472-479* JULY 1970*NO #*EFFECTS OF ATMO-SPHERIC CHANGES ON ATTENUATION IN THE ATMOSPHERE ARE EXAMINED FOR THE 5 MM WAVELENGTH REGION OF THE ELECTRO-MAGNETIC SPECTRUM (48-72 GHZ). ATTENUATION VS FREQUENCY AND ALTITUDE FOR VERTICAL TRANSMISSION THROUGH THE ATMOSPHERE, CAUSED BY OXYGEN ABSORPTION, ARE TABULATED FOR GEOGRAPHICAL AND SEASONAL MODEL ATMOSPHERES. THE ATTENUATING EFFECTS OF WATER FORMATIONS ARE DISCUSSED AND COMPARED TO OXYGEN ATTENUATION.**

621171A*ROSENKRANZ, PHILIP W.*SHAPE OF THE 5 MM OXYGEN BAND IN THE ATMOSPHERE*IEEE TRANSACTION ON ANTENNAS AND PROPAGA-TION, VOL. AP-23, NO. 4, 498-506*JULY 1975*NO #*THE PROBLEM OF ABSORPTION OFMICROWAVES BY MOLECULAR OXYGEN IN THE ATMO-SPHERE IS TREATED BY A FIRST ORDER APPROXIMATION TO THE IMPACT THEORY OF OVERLAPPING SPECTRAL LINES. BY INCLUDING

ONLY THE COUPLING BETWEEN ADJACENT ROTATIONAL STATES IN MOLECULAR COLLISIONS, WE HAVE DEVISED A SIMPLE APPROXIMATION METHOD FOR COMPUTING THE INTERFERENCE BETWEEN LINES FROM MEASUREMENTS ON THE RESOLVED LINES.**

B51581E*SMITH, DONALD R. AND LOEWENSTEIN, ERNEST V.*OPTICAL CONSTANTS OF FAR INFRARED MATERIALS, 3: PLASTICS*APPLIED OPTICS, VOL. 14, NO. 6, 1335-1341*JUNE 1975*NO #*ROOM TEMPERATURE OPTICAL CONSTANTS (INDEX OF REFRACTIONS AND ABSORPTION COEFFICIENT) OF PLASTIC MATERIAL WERE MEASURED OVER THE 50 CM-1 TO 350 CM-1 (200 UM - 28.6 UM) SPECTRAL RANGE. THE MATERIALS INCLUDE HIGH DENSITY POLYETHELENE, TPX, ACLOR, KAPTON, SURLYN AND MYLER. ALL EXCEPT TPX EXHIBIT BIREFRINGENCE AS A CONSEQUENCE OF STRETCHING DURING MANUFACTURE. THE AVERAGE OF TWO SETS IS REPORTED HERE. THE REFRACTIVE INDEX WAS CALCULATED FROM THE CHANNELED SPECTRUM AS OBSERVED IN REFLECTION FROM THE EXAMPLE; THE ABSORPTION COEFFICIENT WAS DETERMINED (EXCEPT POLYETHELENE) BY A TRANSMISSION MEASUREMENT.**

B515829*LOEWENSTEIN, ERNEST V.; SMITH, DONALD R.; AND MORGAN, ROBERT L.*OPTICAL CONSTANTS OF FAR INFRARED MATERIALS. 2: CRYSTALLINE SOLIDS*APPLIED OPTICS, VOL. 12, NO. 2, 398-406*FEB 1973*NO #*THE FAR I.R. OPTICAL CONSTANTS OF FOUR CRYSTALLINE MATERIALS AT 300 DEG K AND 1.5 DEG K ARE REPORTED. THESE MATERIALS ARE CRYSTAL QUARTZ, SAPPHIRE, GERMANIUM, AND SILICON. FOR QUARTZ AND SAPPHIRE, BOTH SETS ARE REPORTED (THEY ARE BI REFRINGENT). THE MEASUREMENTS EXTEND FROM 30 CM-1 TO 350 CM-1 (333 UM -- 28.6 UM).

8516A17*BRADLEY, C.C. AND GEBBIE, H.A.*REFRACTIVE INDEX OF NITROGEN, WATER VAPOR, AND THEIR MIXTURES AT SUBMILLIMETER WAVELENGTHS*APPLIED OPTICS, VOL. 10, NO. 4, 755-758*APRIL 1971*NO #*THE REFRACTIVE INDEX OF NITROGEN, WATER VAPOR, AND THEIR MIXTURE WAS MEASURED AT 337 UM, 311 UM AND 28 UM WITH MOLECULAR LASERS. A DISCREPANCY BETWEEN THESE NEW MEASURED VALUES AND MICROAVE VALUES FOR PURE N2 IS UNEXPLAINED.**

9437A17*ROSENBLUH, M.; TEMKIN, R.J.; AND BUTTON, K.J.*SUBMILLIMETER LASER WAVELENGTH TABLES*APPLIED OPTICS, VOL. 15, NO. 11, 2635-2644*NOV 1976*NO #*TABLES PRESENTED THAT LIST SUB MM LASER LINES OBSERVED IN THE OPTICAL PUMPING OF MOLECULAR GASES WITH CO2 LASER RADIATION. THE LINES HAVE BEEN OBTAINED FROM PREVIOUS PUBLICATIONS BY VARIOUS AUTHORS ARE IN THE WAVELENGTH RANGE FROM 34 UM TO 1.965 MM.**

9125819*BLOCK, H. AND NORTH, A.M.*DIELECTRIC RELAXATION IN POLYMER SOLUTIONS*ADVAN. MOL. RELAXATION PROCESSES, VOL. 1, 309-374*1970*NO #*THIS IS A LONG, GENERAL ARTICLE ON DIELECTRIC RELAXATION IN POLYMER SOLUTIONS, TITLES IN THIS MINI-TREATISE ARE CLASSIFICATION OF POLYMER TYPES, POSSIBLE RELAXATION MECHANISMS,THEORY OF DIELECTRIC RELAXATION IN POLYMER SOLUTIONS, DIELECTRIC RELAXATION IN RANDOM COIL MOLECULES, DIELECTRIC RELAXATION OF POLYELECTROLYTE AND ALLIED MACROMOLECULES, AND DIELECTRIC RELAXATION OF RIGID AND LIKE POLYMERS.**

212311C*DINTELMANN, F.*SCATTERING CAUSED BY PRECIPITATION IN THE MILLIMETER WAVELENGTH (3 CM WAVELENGTH)*NO #*NO #*JAN 1972*N73-31100*IN THIS REPORT WE REPORT ON THE CALCULATION OF THE DIFFERENTIAL SCATTERING CROSS SECTION USING MIE'S THEORY. THE SCATTERING CROSS SECTION IS CALCULATED FOR SPHERICAL

PARTICLES WITH COMPLEX INDEX OF REFRACTION. VALUES OF THE SCATTERING CROSS SECTION ARE GIVEN FOR VARIOUS RAIN RATES AND WAVELENGTHS. THE CALCULATIONS ASSUMED LAWS-PAPERS AND BARSBALL-PALMER DROP DISTRIBUTIONS, USING DROPLET DISTRIBUTION MEASURED ON 912817, BY FGR D33, IT IS DEMONSTRATED THAT THE SCATTERING CROSS SECTION MAY NOT BE CHARACTERIZED BY EVEN RATE ONLY.**

2133810*WILEY, P.H.*THE INFLUENCE OF POLARIZATION ON MILLIMETER WAVE PROPAGATION THROUGH RAIN (PHD THESIS)*NO #*NO #*JUNE 1973*N74-10140*THE AUTHOR EXPLORED IN HIS PHD THESIS THE INFLUENCE OF POLARIZATION ON MM WAVE PROPAGATION FROM BOTH AN EXPERIMENTAL AND A THEORETICAL VIEWPOINT. UNIQUE ASPECTS OF THE MODE USED HERE ARE: 1) SPHERICAL RATHER THAN PLANE WAVES ARE ASSUMED, 2) THE AVERAGE DROP DIAMETER IS USED RATHER THAN A DROP SIZE DISTRIBUTION, 3) THEORY IS SIMPLE ENOUGH THAT THE EFFECT OF CHANGING ONE OR MORE PARAMETERS HAS ON THE CROSS POLARIZATION LEVEL IS EASILY SEEN. CONCLUSIONS: 1) THE BEST POLARIZATIONS TO USE FOR A DEPOLARIZATION EXPERIMENT ON ARE PLUS OR MINUS 45 DEG FROM THE VERTICAL, 2) VERTICAL AND HORIZONTAL POLARIZATION SHOULD NOT BE USED FOR A POLARIZATION EXPERIMENT, 3) VERTICAL POLARIZATION SUFFERS THE LEAST AVERAGE ATTENUATION DURING RAINFALL, 4) OBUCHIS ATTENUATIONS AND PHASE CORRECTIONS ARE CORRECT FOR 19.36742, 5) THE EFFECTIVE PERCENT OF OBLATE DROPS ASSUMED IN ANALYSES IS CRITICAL TO THE PREDICTED CROSS POLARIZATION LEVEL, 6) POLARIZATION DIVERSITY IS NOT FEASIBLE AS A MEANS OF INCREASING RESISTANCE TO RAIN-INDUCED FADING _, 7) THE USE OF POLARIZATION MULTIPLEXING UTILIZING ORTHOGONAL POLARIZATIONS IS LIMITED TO VERY SHORT PATH LENGTHS.**

5631838*SMITH, MONA F. , EDITOR*ATMOSPHERIC EFFECTS ON LASER BEAMS, VOL. 1, 1964-1974 (A BIBLIOGRAPHY WITH ABSTRACT)*NO #*NO #*OCT 1976*NTIS/PS-76/0842*THIS IS A 10-YEAR BIBLIOGRAPHY OF ATMOSPHERE EFFECTS ON LASER BEAMS. MOST OF THE ARTICLES DEALWITH VISIBLE AND IR LASERS THROUGH 10.6 UM. THIS MUST BE CONSIDERED AS AN IMPORTANT SOURCE OF DATA ON LIGHT WAVE INTERACTION EFFECTS WITH AEROSOLS AND TURBULENCE EFFECTS OF WAVELENGTHS SHORTER THAN 100 UM.**

521171E*SMITH, IKE*MILLIMETER COMMUNICATION PROPAGATION PROGRAM, FINAL REPORT, VOL. IV.*NAS5-9523,NO #*1965*N66-30305*THIS DOCUMENT IS VOL. III OF THE FINAL REPORT FROM THE MM COMMUNICATION PROGRAM BEING PERFORMED UNDER NASA CONTRACT NO. NAS5-9523 BY RAYTHEON SPACE AND INFORMATION SYSTEMS DIV. FOR GODDARD SPACE FLIGHT CENTER. THE PROGRAM WAS A STUDY TO DESIGN EXPERIMENTS WHICH WERE TO DETERMINE THE EFFECTS OF THE PROPAGATING MEDIUM ON MM WAVE (10-100 GHZ) SPACE LEVEL COMMUNICATIONS. THIS IS A DESCRIPTION BIBLIOGRAPHY OF DOCUMENTS WHICH WERE USED ON THE STUDY. CATEGORIES CONSIDERED: METEOROLOGY, ATMOSPHERIC PROPAGATION, PLASMA EFFECTS CHANNEL CHARACTERIZATION, COMMUNICATION SYSTEM PERFORMANCE, COMMUNICATION SYSTEM APPLICATION, ANTENNAS AND COMPONENTS, CIRCUITSD, EXPERIMENTAL GROUND

523111D*ALTSHULER, E.E. AND EBEOGLER, D.B.*DOD WORKSHOP ON MILLIMETER WAVE TERMINAL GUIDANCE SYSTEMS (SECOND)(ADVERSE WEATHER EFFECTS)*NO #*RADC-TM-76-9*MAY 1976*AD A026 270*

A ONE-DAY WORKSHOP WAS HELD AT THE AF CAMBRIDGE RESEARCH LABORATORIES (AFCRL) ON 28 JUN 1976, ON THE SUBJECT OF MM WAVE MEASUREMENTS IN ADVERSE WEATHER. THIS WORKSHOP WASD ORGANIZED BY THE AF ARMAMENT LAB (AFATL), EGLIN AFB, FL, IN CONJUNCTION WITH AFCRL, HANSCOM AFB, AND WAS A PART OF THE DOD JOINT TECHNICAL COORDINATION GROUP (JTCG), AND THE SENSORS AND SEARCHES GROUP, COORDINATION ACTIVITIES. THE OBJECTIVE OF THIS WORKSHOP WAS TO EXTEND THE LEVEL OF UNDERSTANDING OF THE ADVERSE WEATHER PROBLEM WITHIN THE DOD, SO THAT MM WAVE SYSTEMS CAN BE DESIGNED AND TESTED EFFECTIVELY. THE KEY FREQUENCIES WERE 35 AND 95 GHZ.**

562181E *CORCORAN, V.J.*WORKSHOP ON AMOSPHERIC TRANSMISSION MODELING*DAHC15-73-C-0200*NO #*DEC 1975*AD-A026 354*THIS IS A REPORT ON A WORKSHOP ON ATMOSPHERIC TRANSMISSION MODELING. THE WORKSHOP WAS DIVIDED INTO A MORNING SESSION IN WHICH PAPERS RELATING TO THE TOPIC WERE PRESENTED AND AN AFTERNOON WORKSHOP THAT AS DIVIDED INTO A PHYSICS AND AN ENGINEERING SESSION AND A SESSION ON COMPUTER MODELING. TYHE THE PURPOSE OF THE WORKSHOP WAS TO BRING TOGETHER THOSE PEOPLE WHO HAVE CONTRIBUTED TO COMPUTER MODELING OF ATMO-SPHERIC TRANSMISSION, THOSE WHO USE THE PROGRAMS, AND THOSE WHO HAVE EVALUATED THE PROGRAMS SO THAT A CONSENSUS COULD BE OBTAINED CONCERNING PRESENT MODELS, THE PROBLEM AREAS, AND WHAT MUST BE DONE TO EVOLVE A MODEL OR MODELS THAT WOULD BE ACCEPTABLE IN THE FUTURE.**

511731F*MARTIN, L.U. AND BEARD, C.I.*MICROWAVE RADIOMETRIC DETECTION OF ATMOSPHERIC INTERNAL WAVES*NRL-MR-3283*NO MAY 1976*AD-A026 523*MICROWAVE RADIOMETERS (226 GHZ) HAVE, FOR THE FIRST TIME, DETECTED INTERNAL WAVES IN THE ATMO-SPHERE BOUNDARY LAYERS AND LOCALIZED ALTITUDE. VARYING THE INTERSECTION HEIGHT OF A NARROW (3 DEG) INTERNAL BEAM WITH THAT OF A WIDE (22 DEG) VERTICALLY POINTING ANTENNA BEAM ALLOWED DETERMINATION OF THE WAVE ALTITUDES. THE GROUND-BASED RADIOMETERS WERE LOCATED AT SAN DIEGO, WHERE, IN AN EXPERIMENT IN MAY-JUNE 1975, THE NAVAL ELECTRONIC LABORATORY CENTER (NELC) PROVIDED "ATMOSPHERIC TRUTH" FOR COMPARISON TO THE RADIOMETER DATA OBTAINED BY THE NAVAL RESEARCH LABORATORY, NELC PROVIDED FM/CW RADER, ACOUSTIC SOUNDER, LIDAR, MICROBOROGRAPH, RADIO-SONDE, AND SURFACE METEOROLOGICAL DATA.**

C111719*BARTON,JAMES E.*PERFORMANCE OF A J-BAND (12-18 GHZ) AIR-TO-GROUND WIDEBAND DATA LINK*NO #*NO #*JUNE 1976*AD-A027 191*THIS REPORT DISCUSSES THE EFFECTS OF ADVERSE WEATHER CONDITIONS ON A LONG AIR-GROUND DATA LINK (15 GHZ BAND). IT INCLUDES ATTENUATION DUE TO RAIN AND THE DEGRADA-TION OF ANTENNAE PATTERNS CAUSED BY WATER FILM ABSORPTION ON A RADOME AND ANTENNA FEEDS, AND CONCLUDES THAT THE LINK DISCUSSED FALLS ABOUT 7DB SHORT OF THE REQUIRED MARGIN FOR 1% OF THE YEAR.**

512181B*ROPPEL, D.*PRESENT STATUS OF THE RRI SLANT-PATH ABSORPTION MODEL (SLAM) CO.*NO #*NO #*JAN 1976*AD-A027 215* A COMPUTER PROGRAM (SLAM) IS DESCRIBED WHICH CALCULATES THE ATTENUATION BY AIR OF UWAVE AND MM ATTENUATION. BESIDES THE HORIZONTAL ATTENUATION, THE VERTICAL ATTENUATION FROM VARIOUS LEVELS DOWN TO THE GROUND AND OUT INTO SPACE IS

CALCULATED FOR A FIXED FREQUENCY. THE LINE PROFILE AND ATMOSPHERIC MODEL CAN BE SELECTED FROM AMONG SEVERAL. COMPARISON IS MADE WITH OTHER CALCULATIONS, AND WITH EXPERIMENTS. POSSIBILITIES FOR IMPROVING THE PROGRAM ARE DISCUSSED.**

5623818*USLENGHI, P.L.*PROCEEDINGS OF NATIONAL CONFERENCE ON ELECTROMAGNETIC SCATTERING, JUNE 15-18, 1976*NO #*NO #*JUNE 1976*AD-A027 868*THIS DOCUMENT CONTAINS SUMMARIES OF ALL INVITED AND CONTRIBUTED PAPERS. OTHER PUBLICATIONS (PUBLISHED ELSEWHERE) ARE: REPORTS WITH THE FINDINGS OF VARIOUS PANELS AND FINAL RECOMMENDATIONS TO THE AIR FORCE: AND A BOOK ON ELECTROMAGNETIC SCATTERING CONTAINS THE INVITED PAPER; AND A SELECTION OF CONTRIBUTED PAPERS.**

5631826*HODARA, H., CONF. CHMN.*OPTICAL PROPAGATION IN THE ATMOSPHERE: AGARD CONFERENCE PROCEEDINGS NO. 183*AGARD-CP-183*MAY 1976*AD-A028 615*THIS IS A CONFERENCE PROCEEDINGS OF THE 1976 AGARD CONFERENCE "OPTICAL PROPAGATION IN THE ATMOSPHERE" __. SESSION TITLES ARE I. ATMOSPHERIC CHARACTER-ISTICS, II. INCOHERENT PROPAGATION, III. COHERENT PROPAGA-TION, IV. NON-LINEAR PROPAGATION, V. PROPAGATION LIMITATIONS ON SYSTEMS.**

D12681C*LORTIE, E.L.; KREGEL, M.D.; AND NIBS, F.E.*AIRCHEM: A COMPUTATIONAL TECHNIQUE FOR MODELING THE CHEMISTRY OF THE ATMOSPHERE (BRL REPORT 1913)*NO #*NO #*AUG 1976*AD-A030 157*DEIONIZATION PROCESSES THOUGHT TO DESCRIBE AND HAVE CONCEN-TRATIONS OF ION AND NEUTRAL CONSTITUENTS IN THE IONIZED A NUMBER OF TECHNIQUES OF VARYING COMPLEXITY AND EFFICIENCY. ONE VERY EFFICIENT TECHNIQUE FOR COMPLEX CASES IS THE AIRCHEM COMPUTER PROGRAM. THIS PROGRAM UTILIZES THE K-METHOD FOR SOLVING THE ORDINARY DIFFERENTIAL EQUATIONS WHICH ARISE FROM THE MATHEMATICAL DESCRIPTION OF ATMOSPHERIC DIONIZATION PROCESSES _, MANY OF WHICH ARE CHARACTERIZED BY EXCEEDINGLY SHORT TIME CONSTANTS.**

512681C*TSANG, L. AND KONG, J.A.* _THERMAL MICROWAVE EMISSION FROM HALF-SPACE RANDOM MEDIA *NO #*RADIO SCENE 11, 599-609*FEB 1976*AD-A030 489*BRIGHTNESS TEMPERATURES RESULTING FROM MWAVE THERMAL EMISSION FROM A 1/2 SPACE RANDOM MEDIUM ARE CALCULATED. THE RANDOM MEDIUM HAS A NON-UNIFORM TEM-PERATURE PROFILE AND IS CHARACTERIZED BY CORRELATION FUNC-TIONS THAT POSSESS BOTH VERTICAL AND LATERAL VARIATIONS. RADIATIVE TRANSFER EQUATIONS ARE DERIVED. THEY ARE SOLVED WITH AN ITERATIVE INTEGRAL EQUATION APPROACH FOR SMALL SCATTERING ALBEDO AND WITH A NUMERICAL APPROACH FOR GENERAL CASES. NEW RESULTS ARE ILLUSTRATED, DISCUSSED AND COMPARED WITH VARIOUS SPECIAL CASES.**

C13174A*NO AUTHOR*MILLIMETER WAVES TECHNIQUES CONFERENCE, VOL. 1*NO #*NO #*MAR 1974*AD-A009 512*THIS IS A CONFERENCE PRO-CEEDINGS OF THE 1974 MM WAVES TECHNIQUES CONFERENCE HELD 26-28 MARCH 1974, SPONSORED BY THE NAVAL ELECTRONICS LABORA-TORY CENTER. MAJOR TITLES OF THE CONFERENCE WERE: A) SOLID STATE DEVICES AND COMPONENTS, B) PROPAGATION, ANTENNAES, C) CIRCUIT COMPONENTS, COMMUNICATION _. AN ARTICLE BY VICTOR RICHARD AND J. KAMMERER "MM WAVE RAIN BACKSCATTERING MEASUREMENTS, HAS BACKSCATTER AND WATER DIELECTRIC DATA AT 10, 35, 70 AND 95 GHZ.**

111731E*GORDY, NORMAN C.*REMOTE SENSING OF ATMOSPHERIC WATER CONTENT FROM SATELLITES USING MICROWAVE RADIOMETRY *NO #* IEEE TRANSACTIONS AND PROPAGATION, VOL. AP-24, NO. 2, 155-162* MAR 1976*NO #*ANALYSIS IS PRESENTED WHICH SUBSTANTIATES THE HIGH CORRELATION ACHIEVED IN RELATING INTEGRATED WATER VAPOR AND LIQUID WATER TO BRIGHTNESS TEMPERATURES AT FREQUENCIES NEAR THE 22.235 GHZ WATER VAPORLINE. THE INFLUENCE OF ATMOSPHERIC AND SURFACE VARIABILITY IS SHOWN TO BE MINIMAL OVER LOW EMISSIVITY SEA SURFACES. DETERMINATION OF ATMOSPHERIC WATER CONTENT USING REGRESSION TECHNIQUES IS SHOWN TO FOLLOW DIRECTLY THE NIMBUS-F1 MICROWAVE SPECTROMETER ABOARD NIMBUS -5 ARE COMPARED WITH RADIO-SONDE WATER VAPOR MEASUREMENTS AND CLOUD IMAGES RECORDED BY THE TEMPERATURE HUMIDITY INFRARED RADIOMETER ABOARD NIMBUS-5.**

5111718*NO AUTHOR*SIGNIFICANT ACCOMPLISHMENTS IN TECHNOLOGY AT GODDARD SPACE FLIGHT CENTER (GSFC), NOV 7-8, 1972*NO #* NO #*1973*N73-28716 - N73-27864*THIS IS A COLLECTION OF TALKS GIVEN BY AUTHORS FROM NASA-GODDARD ABOUT SIGNIFICANT ACCOMPLISHMENTS IN 1972 AT GSFC. SPACE SCIENCE AND TECHNOLOGY SUPPORTAVE OF GSFC PROGRAMS IN LAUNCH VEHICLES, VISIBLE AND IR IMAGERY OF THE EARTH COMMUNICATIONS (15 AND 31 GHZ VIS AIS-V) AND ASTRONOMY PROGRAMS ARE DISCUSSED.**

563184B*SMITH, MONA F., EDITOR*ATMOSPHERIC EFFECTS ON LASER BEAMS, VOL. 2. 1975 - SEPTEMBER 1977: (A BIBLIOGRAPHY WITH ABSTRACTS)*NO #*NO #*OCT 1977*NTIS/PS-77/0831*THIS IS A CONTINUATION OF NTIS/PS-76/0842, A BIBLIOGRAPHY ON ATMOSPHERE EFFECTS ON LASER BEAMS. MOST OF THE ARTICLES USE VISIBLE AND IR LASERS UP TO 10.6 UM. THESE BIBLIOGRAPHIES ARE AN IMPORTANT SOURCE OF INFORMATION ON AEROSOLS AND TURBULENCE EFFECTS IN THE ATMOSPHERE.**

B417717*DAVIES, G.J. AND HAIGH, J.*SUBMILLIMETER SPECTRA OF PURE HIGH AND LOW DENSITY POLYETHYLENE*NO #*INFRARED PHYSICS, VOL. 14, 181-188*1974*NO #*AS PART OF A SEARCH FOR A DIELECTRIC OF HIGH MICROWAVE TRANSPARENCY FOR TELECOMMUNICATION APPLICATIONS , THE SPECTRA OF PURE HIGH AND LOW DENSITY POLYETHYLENE, PREPARED BY A MESO PROCESS, HAVE BEEN RECORDED AT SUB-MM WAVELENGTHS.**

922171F*DAVIES, GRAHAM J. AND EVANS, MYRON*USE OF GENERALIZED LANGEVIN THEORY TO DESCRIBE FARINFRARED ABSORPTIONS IN NON-DIPOLAR LIQUIDS*NO #*JOURNAL OF THE CHEMICAL SOCIETY OF LONDON FARADAY II, 72, 1194-1205*1976*NO #*THE MORI CONTINUED FRACTION REPRESENTATION OF THE KVBO RESPONSE FUNCTION, TRUNCATED AT FIRST ORDER, GENERATES A SPECTRAL FUNCTION WHICH IS SUCCESSFUL IN DESCRIBING ABSORPTION OS NON-DIPLOR LIQUIDS IN THE HIGH MICROWAVE AND FAR INFRARED REGIONS. THERE IS SOME EVIDENCE THAT THE EQUILIBRIUM AVERAGES (K0(O) AND K1(O) INHERENT IN THIS REPRESENTATION ARE BOTH INTERMOLECULAR PROPERTIES, IN CONTRAST TO THE CASE OF PURE DIPOLAR ABSORPTION, WHERE K0(O) IS A SINGLE MOLECULE PROPERTY. THE CORRELATION FUNCTION OF THE DERIVED SPECTRAL FUNCTION IS COMPARED AND CONTRASTED WITH THAT OF THE INTENDED DIFFUSION MODEL OF GORDON.**

C11731A*ULABY, F.T.*PASSIVE MICROWAVE REMOTE SENSING OF THE EARTH'S SURFACE*NO #*IEEE TRANSACTIONS ON ANTENNAS & PROPAGATION, 112-115*JAN 1976*NO #*ABSTRACT - THIS IS A BRIEF

REVIEW PAPER ON MICROWAVE RADIOMETRY AS A REMOTE SENSING TOOL IN GEOSCIENTIFIC INVESTIGATIONS. TOPICS COVERED INCLUDE BASIC RADIOMETRIC PRINCIPLES, RADIOMETER RECEIVERS, AND APPLICATIONS _. THIS PAPER IS ONE IN A SERIES OF MINI-REVIEWS SPONSORED BY THE WAVE PROPAGATION STANDARD COMMITTEE OF IEEE AND IS INTENDED PRIMARILY FOR THOSE PERSONS WHO HAVE NOT HAD OCCASION TO STUDY EXTENSIVELY IN THE SUBJECT.**

C312419*BIRCH, J.R.; PRICE, G.D.; AND CHAMBERLIN, J*DISPERSICAL FOURIER TRANSFORM MEASUREMENTS ON OPAQUE SOLIDS FROM 5 TO 350 CM-1*NO #*INFRARED PHYSICS, VOL. 16, 311-315*1976* NO #*A TWO-BEAM INTERFEROMETER FOR USE IN AMBIENT TEMPERATURE DISPERSIVE FOURIER TRANSFORM MEASUREMENTS ON OPAQUE OR HIGHLY REFLECTING SOLIDS IS DESCRIBED. THE SPECTRAL RANGE BETWEEN 5 AND 350 CM-1 HAS BEEN COVERED AND THE PERFORMANCE ILLUSTRATED WITH THE FIRST REPORTED DIHYDROGEN PHOSPHATE AND AMMONIUM DIHYDROGEN PHOSPHATE.**

C415516*MELCHOIRRI, B; NATALE, V.; FISCELLA, B.; AND LOMBARDINE, P.*MATERIALS SUITABLE FOR MAKING FILTERS BEYOND 30 DEG UM* NO #*INFRARED PHYSICS, VOL. 16, 253-255*1976*NO #*MATERIALS SUITABLE FOR MAKING FILTERS IN THE FAR INFRARED BETWEEN 300 AND 2000 UM ARE INVESTIGATED BY MEANS OF A MICHELSON INTER-FEROMETER AND MONOCHROMATIC RADIATION OBTAINED BY A KLYSTRON.**

5317319*MATHER, J.C.; RICHARDS, P.L. AND WOODY, D.P.* _BALLOON-BASED MEASUREMENTS OF THE COSMIC BACKGROUND RADIATION*NO #* IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. MTT-22, NO. 12, 1046-1048*DEC 1974*NO #*WE HAVE DEVELOPED AND FLOWN A BALOON-BORNE LIQUID-HELIUM-COOLED SPECTROMETER TO MEASURE THE COSMIC BACKGROUND RADIATION IN THE 3-18-CM REGION. IT FEATURES A COOLED HORN ANTENNA, A POLARIZING MICHELSON INTERFEROMETER, AND A GERMANIUM BOLOMETER. THESE DESIGN FEATURES AND THE PERFORMANCE OF THE INSTRUMENT ARE DISCUSSED.**

2221718*MALINKIN, V.G.; SOKOLOV, A.V. AND SICKHONIN, YE.V.* ATTENUATION OF SIGNAL AT THE WAVELENGTH LAMBDA - 8.6 MM IN HYDROMETEORS*NO #*RADIO ENG. & ELECTRONICS PHYSICS, VOL. 21, NO. 4, 1-4*APR 1976*NO #*THE ATTENUATION OF RADIATION AT THE WAVELENGTH OF 8.6 MM WAS INVESTIGATED DURING RAIN AND SNOWFALL ON A 5.6 KM LONG LINK IN THE VICINITY OF MOSCOW. IT WAS SHOWN THAT FOR RAIN OF AVERAGE INTENSITY OF 1-8 MM/HR THE ATTENUA-TION ON THE LINK WAS ABOUT 0.8 DB.**

C131738*REED, WILLIAM E.*MICROWAVE COMMUNICATIONS, VOL. 2, APRIL 1976 - MAY 1977*NO #*NO #* _JUNE 1977*NTIS/PS-77/0466* RESEARCH REPORTS PERTINENT TO THE TECHNIQUES, EQUIPMENT, RELIABILITY, AND UTILIZATION OF UWAVE COMMUNICATIONS ARE CITED. STUDIES ON MWAVE RELAYS, DATA TRANSMISSION, TELEMETRY SATELLITE COMMUNICATION, MULTIPLEXING, AND PROPAGATION ARE INCLUDED. THIS UPDATED BIBLIOGRAPHY CONTAINING 100 ABSTRACTS, ALL OF WHICH ARE NEW ENTRIES TO THE PREVIOUS EDITION.**

C131728*REED, WILLIAM E.*MICROWAVE COMMUNICATION, VOL. I, 1964 - MARCH 1976 (A BIBLIOGRAPHY WITH ABSTRACTS)*NO #*NO #*NTIS/ PS-77/0465*RESEARCH REPORTS PERTINENT TO THE TECHNQUES, RELIABILITY, AND UTILIZATION OF MWAVE COMMUNICATIONS ARE CITED. STUDIES ON UWAVE RELAYS, DATA TRANSMISSION, TELEMETRY SATELLITE COMMUNICATION, MULTIPPLEXING, AND PROPAGATION ARE INCLUDED. (THIS UPDATED BIBLIOGRAPHY CONTAINS 221 ABSTRACTS, NONE OF WHICH ARE NEW ENTRIES TO THE PREVIOUS EDITION.)**

562181B*RODGERS, C. D.*APPROXIMATE METHODS OF CALCULATING TRANSMISSION BY BANDS OF SPECIAL LINES _*NSF C-760*NO #*MAR 1976*PB-252 367*THIS PAPER DESCRIBES APPROXIMATIONS THAT HAVE BEEN FOUND USEFUL IN CALCULATING THE TRANSMISSION OF MOLECULAR GASES IN PLANETARY ATMOSPHERES. THIS INCLUDES THE USE OF BAND MODELS AND EMPIRICAL MODELS, BUT NOT THE MORE COMPLEX _"LIVELY LINE" METHODS. A VARIETY OF TECHNIQUES ARE DESCRIBED FOR DEALING WITH THE CASE OF TRANSMISSION THROUGH AN ATMOSPHERIC PATH WHICH IS HOMOGENEOUS IN THE DISTRIBUTION OF TEMPERATURES _, PRESSURE AND ABSORBER CONCENTRATION. AN EXTENSIVE BIBLIOGRAPHY IS INCLUDED.**

B524A1F*WARD, GRAY*ELECTROMAGNETIC SCATTERING FROM IRREGULARLY SHAPED DIELECTRIC PARTICLES USE VECTOR GREEN'S FUNCTIONS*NSF GK-42718*NO #*OCT 1975*PB-252 413*SCATTERING OF E & M RADIATION FROM AN IRREGULAR DIELECTRIC PARTICLE WHOSE DIMENSION _S ARE COMPARABLE TO THE CONSISTENT WAVELENGTH IS SOLVED AS A CLASSICAL BOUNDARY VALUE PROBLEM IN WHICH THE VECTOR GREEN'S THEOREM IS USED AS A GENERALIZED BOUNDARY CONDITION. THE INSCRIBED SPHERE, THE PARTICLE SURFACE AND THE CIRCUMSCRIBED SPHERE DIVIDE SPACE UP INTO FOUR REGIONS. VECTOR SPHERICAL HARMONIOUS EXPANSION ARE USED OUTSIDE THE CIRCUMSCRIBED SPHERE AND INSIDE THE INSCRIBED SPHERE; ANY CONVENIENT COMPLETE SET OF FUNCTION CAN BE USED IN THE REGIONS IN BETWEEN. THE RESULTING VECTOR EQUATIONS ARE REDUCED TO A SET OF 4 L(L+2) LINEAR EQUATIONS WHERE L IS THE MAXIMUM ORDER OF THE SPHERICAL MULTIPLE NEEDED TO DESCRIBE THE SCATTERED FIELD. 47 REFS.**

512671C*JONES, R. MICHAEL*A VERSATILE THREE-DIMENSIONAL RAY TRACING COMPUTER PROGRAM FOR RADIO WAVES IN THE IONOSPHERE*NO #*NO #*OCT 1975*PB-248 856*THIS REPORT DESCRIBES AN ACCURATE VERSATILE FORTRAN COMPUTER PROGRAM FOR TRACING RAYS THROUGH AN ANISOTROPICMEDIUM WHOSE INDEX OF REFRACTION VARIES CONTINUOUSLY IN 3 DIRECTIONS. ALTHOUGH DEVELOPED TO CALCULATE THE PROPAGATION OF RADIO WAVES IN THE IONISPHERE, THE PROGRAM CAN EASILY BE MODIFIED TO DO OTHER TYPES OF RAY TRACING BECAUSE OF ITS ORGANIZATION INTO SUBROUTINES. THE DOCUMENTATION INCLUDES EQUATIONS, FLOW CHARTS, PROGRAM LISTINGS WITH COMMENTS _, DEFINITIONSOF PROGRAM VARIABLES, DECK SET UPS, DESCRIPTION OF INPUT AND OUTPUT, AND A SAMPLE CASE.**

C23172B*SUNDBERG, G.G.*MILLIMETER WAVE SYSATEM ELECTROMAGNETIC COMPATIBILITY STUDY*CONTRACT DHAB07-74-C-0171*NO #*JUN 1974*AD-922 973*THIS REPORT PRESENTS THE RESULTS OBTAINED DURING THE FIRST QUARTER EFFORT OF THE MM WAVE EMC STUDY. THE PERIOD COVERED IS 6 FEB 74 - 6 MAY 74. THE MAJOR EFFORT IN THE FIRST QUARTER CONSISTED OF THE COLLECTION OF DATA FROM PREVIOUS PROGRAMS WHICH ARE RELATED TO THE MM WAVE EMC STUDY AND PRELIMINARY TEST PLANNING FOR THE EXPERIMENTAL TEST PROGRAM. MM WAVE SYSTEM OPERATIONS RELATIVE TO EMC CHARACTERISTICS IS SUMMARIZED. THE ATMOSPHERIC CONDITIONS AND ANTEWINDOWS ARE DESCRIBED WITHIN THIS DOCUMENT.**

222172E*DUDZINSKY, S.J.*ATMOSPHERIC EFFECTS ON TERRESTRIAL MILLIMETER-WAVE COMMUNICATION*DAHC15-73-C-0181*NO #*MAR 1974*AD-780 602*A METHODOLOGY FOR QUANTITATIVELY ESTIMATING THE PERFORMANCE OF MM WAVE (30-300 GHZ) SYSTEM IN THE ATMOSPHERE AND ON THE PRESENCE OF RAINFALL. INFORMATION ON THE TRANSMISSION PROPERTIES OF MM WAVES IS COMBINED WITH CURRENTLY

AVAILABLE METEOROLOGICAL DATA TO DERIVE THE METHODOLOGY. THE AVAILABLE PROPAGATION AND RAINFALL DATA FOR A GIVEN CLIMACTIC REGION ARE USED TO DERIVE CURVES GIVING ATTENUATION DUE TO RAINFALL VS PATH LENGTH FOR VARIOUS FREQUENCIES. EMPHASIS IS ON HIGH RELIABILITY COMMUNICATIONS IN WHICH OUTAGES ARE 0.1 PERCENT (530 MM/YR) OR LESS, BUT THE METHODOLOGY DESCRIBED APPLIES TO HIGHER OUTAGE SYSTEMS AS WELL.**

5221719*VOGLER, L.E. AND WOOD, L.E.*35 GHZ STRATOSPHERIC PROPAGATION _*ACC-ACO-3-74*NO #*APR 1974*AD-779 519*A RECORD TRANSLATION OF A RUSSIAN PAPER PURPORTS TO HAVE ESTABLISHED A NEW LONG WAVE COMMUNICATION LOOK AT 30-45 GHZ USING REFLECTIONS FROM A STRATOSPHERIC LAYER. BECAUSE OF CERTAIN QUESTIONABLE ASPECTS OF THAT TRANSLATION, A STUDY WAS UNDERTAKEN TO VERIFY THE ARTICLE. IT IS CONCLUDED THE ARTICLE WAS A HOAX, OR THEY WERE MAKING USE OF THE WHISPERING GALLERY EFFECT.**

222181A*BRINKS, W.J.*A DISCUSSION OF EXCESSIVE RAINFALL ATTENUATIONS AT MILLIMETER WAVELENGTHS*HDL-TM-73-14*NO #*JUL 1973*AD-776 342*THIS IS A DISCUSSION OF MIE-STRATTON THEORY OF E & M SCATTERING OF RAIN; SOME RUSSIAN INVESTIGATORS PRODUCED SOME DATA WHICH IS HARD TO UNDERSTAND IN THE MIE THEORY USING DIELECTRIC DATA OF WATER THOUGHT TO BE ACCURATE. THE AUTHOR POINTS OUT THAT TRACE POLLUTANTS IN THE WATER MAY HAVE ALTERED THE RAIN CONDUCTIVITY GIVING THE HARD-TO-UNDERSTAND RESULTS. WAVELENGTH COVERAGE .86 MM - 8 MM. THE COMPLEX INDEX OF WATER IS GIVEN VS WAVELENGTH. 25 REFS.**

9317319*HOUCK, J.R.; SOIFER, B.T. AND HORWIT, M.O.*THE FAR INFRARED AND SUBMILLIMETER BACKGROUND*NO #*NO #*SEPT 19 AD-763 139*WE HAVE REPEATED OUR EARLIER OBSERVATIONS OF THE IR AND SUB MM BACKGROUND RADIATION. WHILE THE MEASURED VALUES OF THE IR BACKGROUND REMAIN UNCHANGED, WE HAVE FAILED TO OBSERVE THE HIGH FLEX PREVIOUSLY REPORTED FOR THE 0.4-1.3 MM RANGE. THIS INDICATES THAT THE FLUX CANNOT HAVE BEEN GALACTIC OR COSMIC, BUT FURTHER OBSERVATIONS ARE NEEDED TO RUB OUT A SOLAR CYCLE DEPENDENT GEOCORONAL ORIGIN.**

5131816*NO #*PROPAGATION EFFECTS ON FREQUENCY SHARING*AGARD-CP-127*NO #*1973*AD-769 376*THIS IS AN AGARD CONFERENCE PROCEEDING COVERING 4 AREAS: 1) PROPAGATION OVER IRREGULAR TERRAIN, 2) INTERFERENCE DUE TO PRECIPITATION SCATTER, 3) CONTROL OF ANTENNAE SIDELOBES, 4) PROPAGATION DATA FOR INTERFERENCE PROBABILITY DETERMINATION.**

B315818*SHCHERBOV, V.A. AND IKULESHOVE, E.M.*MEASURING THE DIELECTRIC CONSTANT OF MATERIALS IN THE MILLIMETER WAVE RANGE (1-6 MM)*NO #*NO #*MAR 1971*AD-727 941*A PROCEDURE IS INVESTIGATED FOR MEASURING THE DIELECTRIC CONSTANT E OF HOMOGENEOUS AND INHOMOGENEOUS SUBSTANCES USED IN THE MM AND SUB MM WAVE RANGE. THE DETERMINATION OF E IS BASED ON MEASURING THE OPTICAL THICKNESS OF THE SAMPLE AT THE UWAVE PHASE SHIFT CAUSED BY THE STEP OF THE INVESTIGATED SAMPLE.**

433181D*STEWART, D.A.*INFRARED AND SUBMILLIMETER EXTINCTION BY FOG*DRDMI-TR-77-9*NO #*JUL 1977*AD-A045 181*A THOROUGH LITERATURE SURVEY OF FOG DROP SIZE DISTRIBUTIONS THROUGHOUT THE WORLD IS DISCUSSED, AND DATA FROM 36 REFERENCES ARE SUMMARIZED. THE REVIEW OF AN EXTENSIVE LIST OF OVER 100

REFERENCES INCLUDES ADDITIONAL IMPORTANT INFORMATION. RANGES OF LIQUID WATER CONTENT AND PROBLEMS OF RELATING THIS TO VISIBILITY ARE EXAMINED. CHANGES IN FOG CHARACTERISTICS FROM PHASE TO PHASE AND FROM TIME TO TIME ARE ALSO CONSIDERED, AND THE DISCUSSION INCLUDES SMALL-SCALE SPATIAL AND TEMPORAL FLUCTUATIONS. A REPRESENTATIVE SAMPLE OF DATA IS USED TO COMPUTE EXTINCTION OF E & M ENERGY WITH WAVELENGHTS OF 0.55, 10.5, 870, AND 1250 UM.**

B11161G*BOLLEN, R.L.; HATFIELD, V.E. AND CHESNUT, W.G.*PREDICTIONS OF EFFECTS PRODUCED BY THE DICE THROW DETONATION ON EXPERIMENTAL MICROWAVE LINKS*NO #*NO #*SEPT 1976*AD-A040 907*THE DUST CLOUDS PRODUCED BY NEAR SURFACE NUCLEAR EXPLOSIONS AND LARGE YIELD H.E. SIMULATIONS OF THESE ARE STUDIED IN ORDER TO PRODUCE PREDICTIONS OF PHASE AND AMPLITUDE FLUCTUATIONS OF UWAVE SIGNALS (10 GHZ) THAT TRANSIT THROUGH THESE CLOUDS. QUANTITATIVE PREDICTIONS ARE MADE BASED ON THEORETICAL PREDICTIONS OF THE DUST CLOUD THAT IS EXPECTED TO BE PRODUCED BY THE 600 FOR ANFO. HE TEST CODE NAMED DICE THROW. THES _E PREDICTIONS ARE MADE FOR THE PATHS AND FREQUENCIES THAT WILL BE USED IN AN EXPERIMENT _AL PROBING BY UWAVE LINKS OF THE DICE THROW DUST CLOUD. A GIVEN IN ORDER TO DETERMINE THE DETONATION ALTITUDE OF A NUCLEAR DEVICE THAT WILL BE SIMULATING THE DICE THROW TEST.**

B636814*NO *OPTICAL PHENOMENA IN INFRARED MATERIALS*NO #*NO #*1976*AD-A037 737*A DIGEST OF THE TECHNICAL PAPERS PRESENTED AT A TOPICAL MEETING ON OPTICAL PHENOMENA IN IR MATERIALS, DEC 1-3, 1976, ANNAPOLIS, MD, 206 PGS.**

5131836*BIONDI, M.A.*ATOMIC AND MOLECULAR PROCESSES IN ATMOSPHERIC ENVIRONMENTS*DA-31-124-ARO-D-440*NO #*SEPT 1975*AD-A017 206*THE RESEARCH TOPICS CARRIED OUT UNDER THIS 10-YEAR CONTRACT ARE STATED AND REFERENCES ARE GIVEN TO THE PUBLICATIONS RESULTING FROM THE RESEARCH. THE PERSONNEL SUPPORTED BY THE CONTRACT ARE LISTED.**

52 1816*GUENTHER, B.D.; BENNETT, J.S.; AND GAMBLE, W.L.*SUBMILLIMETER RESEARCH: A PROPAGATION BIBLIOGRAPPHY _*RR-77-3*NO #*NOV 1976*AD-A037 178*THIS REPORT ISAN ANNOTATED BIBLIOGRAPHY ON THE SUBJECT OF SUB MM PROPAGATION. SEVERAL ARTICLES ARE RECOMMENDED AS A GOOD STARTING POINT FOR REVIEWING THE CURRENT STATE OF THE ART. 136 REFS.**

C312117*GUENTHER, B.D.*SUBMILLIMETER RESEARCH: PRELIMINARY REPORT ON MILLIMETER AND IR*RR-77-4*NO #*NOV 1976*AD-A035 760*A SUMMARY OF THE TYPE OF IMAGES OBTAINED AT 3.2 MM AND 10.6 UM ARE PRESENTED ALONG WITH SAMPLES OF THE IMAGES. RESOLUTIONS OBTAINABLE WERE 10 CM WITH THE 3.2 MM RADAR, 5 CM WITH THE 10.6 UM LASER RADAR, AND 4 CM WITH VISIBLE LIGHT.**

5631816*DOWNS, A.R.*A REVIEW OF ATMOSPHERIC TRANSMISSION INFORMATION IN THE OPTICAL*BRL-MR-2710*NO #*DEC 1976*AD-A035 059*THIS REPORT IS AN ATTEMPT AT CONSOLIDATION OF A LOT OF INFORMATION OF ATMOSPHERIC ATTENUATION; IN WAVEBANDS FROM THE VISIBLE TO 9 GHZ. IT DISCUSSES ATTENUATION DUE TO RAIN, SMOKE, DUST. RECOMMENDATIONS FOR FURTHER MEASUREMENTS ARE GIVEN.**

C211718*FLIEGLER, E.*A 60 GHZ DIGITAL FM SIMPLEX SYSTEM*ECOM-4434*NO #*SEPT 1976*AD-A033 115*A 60 GHZ DIGITAL FM SIMPLEX RADIO UTILIZING WAVEGUIDE IS DESCRIBED. THE SYSTEM IS

OPERATIONAL AND WILL BE USED AS A REFERENCE TO BE COMPARED WITH FUTURE INTEGRATED CIRCUIT AND HYBRID MM RADIOS. A GUNN LOCAL OSCILLATOR WAS DEVELOPED WHICH AFFECTS SIGNIFICANT RECEIVER NOISE REDUCTION. SUBSYSTEM MEASUREMENTS SHOW GOOD CHARACTERISTICS FOR 1 KM PROPAGATION.**

562682G*BISSONNETTE, L.R.*PROBABILITY DISTRIBUTION AND ASYMPTOTIC VARIANCE OF STRONG IRRADIANCE FLUCTUATION OF OPTICAL WAVES IN TURBULENT MEDIA*DREV-R-4042/75*NO #*OCT 1973* AD-A021 126*THE ASYMPTOTIC SOLUTIONS FOR THE FIRST AND SECOND CODE STATISTICAL MOMENTS OF THE AMPLITUDE OF A PLANE OPTICAL WAVE PROPAGATING IN A TURBULENT ATMOSPHERE ARE DERIVED FROM MAXWELLS EQUATION. THESE SOLUTIONS SHOW THAT THE IRRADIANCE VARIANCE WOULD DIVERGE TO INFINITY IF THE PROBABILITY DISTRIBUTION WERE LOG-NORMAL, BUT THAT IT COULD TEND TO UNITY IF THIS DISTRIBUTION WERE NORMAL. THEREFORE, THE WIDELY USED HYPOTHESIS OF LOG-NORMAL PROBABILITY DISTRIBUTION IS INCOMPATIBLE WITH THE EXPERIMENTAL OBSERVATION OF THE SATURATION OF THE IRRADIANCE VARIANCE. AN ORDER OF MAGNITUDE ESTIMATE OF THE PROPAGATION DISTANCE CHARACTERISTIC OF THESE ASYMPTOTIC SOLUTIONS INDICATE THAT THEY SHOULD APPLY IN THE SATURATION REGION. 22 REFS.**

952541G*PASSCHIER, W.F.; HORIJK, D.D.; AND MANDEL, M.*THE DETERMINATION OF COMPLEX REFRACTIVE INDICES WITH FOURIER-TRANSFORM INTERFEROMETRY IV: ERROR ANALYSIS OF FREE LAYER EXPERIMENTS*NO #*INFRARED PHYSICS, VOL. 16, 389-401*1976* NO #*AN ANALYSIS IS PRESENTED OF THE ERRORS IN THE COMPLEX REFRACTIVE INDEX SPECTRUM OF LIQUIDS IN THE FAR I.R. REGION (2-.002 MM, 5-500 CM-1) AS DETERMINED BY FREE LAYER EXPERIMENTS. THE SPECIMEN TRANSMISSION METHOD IS FOUND TO BE THE MOST RELIABLE IF EDITING METHODS CAN BE APPLIED. IT IS FURTHER CONCLUDED THAT REPEATING OF A SINGLE MEASUREMENT IS NOT NECESSARY, BUT THAT EXPERIMENTS AT SEVERAL SPECIMEN THICKNESSES IS OBLIGATORY. IT IS SHOWN THAT THE ERROR DUE TO THE VAPOR PHASE ABOVE THE LIQUID SPECIMEN CAN BE QUITE SUBSTANTIAL. A COMPARISON OF THE ERROR ANALYSIS WITH SOME EXPERIMENTAL RESULTS IS GIVEN FOR BROMOFORM, CHLOROBENZINE AND METHANOL.**

951641A*AFSAR, M.N.; CHAMBERLAIN, J.; AND HASTED, J.B.*THE MEASUREMENT OF THE REFRACTION SPECTRUM OF A LOSSY LIQUID IN THE FAR INFRARED REGION*NO #*INFRARED PHYSICS, VOL. 16, 587-599*1976*NO #*DISPERSIVE FOURIER TRANSFORMS SPECTROMETRY FOR THE DETERMINATION OF THE REFRACTION SPECTRUM OF A LOSSY LIQUID IS DESCRIBED. THE PRINCIPLE OF FIRST ORDER SUBTRACTION PROCEDURE AND FULL DETAILS OF HOW TO USE IT WITH SAMPLED INTERFEROGRAMS ARE GIVEN. THE NEW RESULTS)ON CHLOROBENZENE FOR 1/LAMBDA = 30 CM-1 TO 110 CM-1) ARE COMPARED WITH RESULTS OBTAINED USING OTHER TECHNIQUES.**

943551D*EVANS, M. AND DAVIES, G.J.*EFFECT OF PRESSURE AND TEMPERATURE ON THE INTERMOLECULAR MEAN SQUARE TORQUE IN LIQUID CS2 AND CCL4*NO #*JOURNAL OF THE CHEMICAL SOCIETY OF LONDON, FARADAY II, VOL. 72, 1206-1213*1976*NO #*THE EFFECTS OF TEMPERATURE AND PRESSURE ON THE INTERMOLECULAR MEAN SQUARE TORQUE IN LIQUID CS2 AND CCL4 ARE ESTIMATED USING THE INDUCED ABSORPTION BANDS OF THESE LIQUIDS IN THE MM BAND, 2-300 CM-1 (.5 CM - .00333 CM). THE SPECTRUM WAS

OBTAINED WITH THE NPL GRUBB PARSONS CUBE INTERFEROMETER; A LIQUID HELIUM CODED INSB DETECTOR WAS USED FOR 2-31 CM-1; A GOLAY CALL WAS USED FOR THE WAVE NUMBER RANGE 20-200 CM-1. THE ABSORPTION COEFFICIENTS ALPHA(GAMMA) WERE CALCULATED USING STANDARD FOURIER TRANSFORMATION.**

9416518*CHAMBERLAIN, J.; AFSAR, M.N.; AND HASTED, J.B.*DIRECT MEASUREMENT OF THE REFRACTION SPECTRUM OF ETHANOL AT SUBMILLIMETER WAVELENGTHS _*NO #*NATURE PHYSICAL SCIENCE, VOL. 245, 28-30*SEPT 10, 1973*NO #*THE REAL PART OF THE REFRACTION SPECTRUM FOR ETHANOL IS PRESENTED HERE; EXPERIMENTS WERE PERFORMED AT 22 DEC C FOR A WAVENUMBER RANGE CM-1 (.5 MM) TO 120 CM-1 (83 UM) WITH A CUBE INTERFEROMETER WITH PHASE MODULATION.**

5631A1A*SALISBURY, G.L.*A FAR-INFRARED LASER COMMUNICATION SYSTEM USING THE HYDROGEN CYANIDE LASER*GEO/PH/75-12* NO #*DEC 1975*AD-A019 860*AN ANALYSIS OF A FAR IR LASER COMMUNICATION SYSTEM USING THE HCN LASER. THE HCN LASING WAVELENGTH OF 337 UM FALLS WITHIN THE 350 UM ATMOSPHERIC WINDOW AND PROVIDE THE IMPETUS FOR A LASER COMMUNICATION SYSTEM. THE SYSTEM COMPONENTS THAT ARE EXAMINED INCLUDE THE HCN LASER, FAR I.R. DETECTOR, MODULATORS, AND OPTICAL COMPONENTS. ADDITIONALLY, ATMOSPHERIC PROPAGATION PHENOMENA ARE EXAMINED AT 337 UM. 129 REFS.**

5627319*WEICHEL, R.L.*COMBINED MICROWAVE-INFRARED SOUNDING STUDIES*F19628-75-C-0062*NO #*JAN 1976*AD-A022 681*THE REPORT DESCRIBES THE IMPLEMENTATION AND CHARACTERISTICS OF TWO SOFTWARE SYSTEMS, THE STATISTICAL METHOD OF PARAMETER EXTINCTION (ENVIRONMENTAL RESEARCH & TECHNOLOGY INC.), AND THE MINIMUM INFORMATION METHOD (AF GLOBAL WEATHER CENTRAL). THESE SYSTEMS ARE DESIGNED FOR INVESTIGATING THE RETRIEVAL OF ATMOSPHERIC TEMPERATURE PROFILES FROM REMOTELY SENSED RADIOMETRIC DATA.**

522181A*LAROCCA, A.J. AND TURNER, R.E.*ATMOSPHERIC TRANSMITTANCE AND RADIANCE: METHODS OF CALCULATION*CONTRACT N00014-73-0321-0002*NO #*JUNE 1975*AD-A017 459*THIS IRIA REPORT IS A DESCRIPTION OF STATE OF THE ART METHODS OF CALCULATING ATMOSPHERIC TRANSMITTANCE AND RADIATIVE TRANSFER. THE REPORT IS BROADLY DIVIDED INTO THE CATEGORIES OF SCATTERING AND ABSORPTION, WITH THE GREATER STRESS LAID ON ABSORPTION. THE ESSENTIAL MATERIAL IS PRESENTED IN SECTIONS 3, 6, 7, & 8, IN WHICH SPECIFIC METHODS ARE DESCRIBED.**

562681A*FANTE, RONALD L.*OPTICAL BEAM PROPAGATION IN TURBULENT MEDIA*AFCRL-TR-75-0439*NO #*AUG 1975*AD-A018 061*WE HAVE DISCUSSED AND EXTENDED THE MOST RECENT DEVELOPMENT ON THE PROPAGATIONOF UWAVE AND OPTICAL BEAMS IN TURBULENT MEDIA. SUCH AS THE CLEAR ATMOSPHERE. AMONG THE PHENOMENA CONSIDERED ARE BEAM SPREADING, BEAM WANDER, LOSS OF COHERENCE, SCINTILLATIONS, ANGLE OF ARRIVAL VARIATIONS, AND SHORT PULSE EFFECTS. ALSO INCLUDED IS A DISCUSSION OF METHODS OF COMPENSATION OF THE EFFECT OF TURBULENCE ON COMMUNICATIONS AND IMAGING SYSTEMS. 172 REFERENCES.**

562878l8*BORTNER, M.H. AND BAURER, T.*DEFENSE NUCLEAR AGENCY REACTION RATE HANDBOOK, SECOND EDITION*NO #*NO #*JUNE 1975* AD-A018 386*THIS IS A COMPILATION OF ION-NEUTRAL REACTIONS

RATE CONSTANTS OF ATMOSPHERICALLY IMPORTANT SPECIES. THE REACTIONS REPORTED ARE POSITIVE AND NEGATIVE ION CHARGE - TRANSFER (ELECTRON TRANSFER) WITH NEUTRALS, ION-ATOM-INTER-CHANGE REACTIONS (CHEMICAL REARRANGEMENTS) _, AND 3-BODY ASSOCIATION REACTIONS.**

C111119*SKOLNIK, M.I.*REVIEW OF CURRENT RADAR INTERESTS AND EXTENDING THE RADAR SPECT....*NRL-M5/R-2869*NO #*AUG 1974*AD-785-007*THIS REPORT CONSISTS OF TWO PAPER THAT ARE CONCERNED WITH CURRENT RADAR INTEREST. IN ONE PAPER, THE VARIOUS MAJOR APPLICATIONS ARE DESCRIBED AND A LISTING OF CURRENT PROBLEM AREAS ARE GIVEN. THE OTHER PAPER DISCUSSES THE EXTENSION OF RADAR OUTSIDE THE NORMAL UWAVE BANDS TO INCLUDE THE HF REGION AND ONE END OF THE SPECTRUM AND MM WAVES AT THE OTHER END.**

252581A*DEIRMENDJIAN, D.*FOR INFRARED AND SUBMILLIMETER SCATTERING. I. THE OPTICAL CONSTANTS OF WATER, A SURVEY* NO #*NO #*FEB 1974*AD-787 205*THIS IIS A LITERA-TURE SURVEY OVER THE OPTICAL CONSTANTS OF LIQUID WATER FROM 15U TO 1000U IN 1974. HE CONCLUDES THAT THE CONSTANTS ARE FAIRLY WELL KNOWN IN THE ENTIRE RANGE UP TO MM WAVES. OPTICAL CONSTANTS FOR ICE IN THE SAME WAVELENGTH RANGE ARE LESS WELL KNOWN; ICE PARTICLES ARE NON SPHERICAL AND PRESENT THEORY DOES NOT EXIST FOR THE EXOTIC SHAPE THER CRYSTALS TAKE.**

C11411D*DYANA, A.C.*RADAR REFLECTIVITY MEASUREMENTS SYMPOSIUM, M.I.T., 1964*RADC TDR-64-23, VOL. I*NO #*APRIL 1964*AD 601 364*THIS REPORT IS A COLLECTION OF TECHNICAL PAPERS REVIEWED AND DISCUSSED AT THE SYMPOSIUM ON RADAR REFLECTIVITY MEASURE-MENTS ON JUNE 2-4, 1964 AT MIT. THE PRIME GOAL OF THE SYMPOSIUM IS THE EXCHANGE OF IDEAS AND INFORMATION RELATIVE TO RESEARCH EFFORTS, PAST, PRESENT AND FUTURE IN THE FIELD OF RADAR REFLECTIVITY MEASUREMENTS. THE TECHNICAL PAPERS DWELL ON THE FOLLOWING REFLECTIVITY RANGE SUBJECTS: GEOMETRY, AND TECHNIQUES, SPECIAL EQUIPMENT, MODELS, MODEL SUPPORTS, SPECIAL MATERIALS, CALIBRATION, RANGE INTERCALIBRATION, MEASUREMENTS PROCEEDING DATA STANDARDS, CORRELATION AND APPLICATIONS.**

B125869*BELLEMANS, A*STATISTICAL THEORY OF ELECTRIC POLARI-ZATION*W-31-104-EIV 6-38*NO*AUG 1967*ANL-7381*THIS REPORT CORRESPONDS TO A SERIES OF SIX LECTURES GIVEN TO THE MEMBERS OF THE SOLID STATE SCIENCE DIVISION OF ARGONNE NATIONAL LABS IN AUG 1967. THE MATERIAL PRESENTED HERE GIVES A REVIEW OF THE PRESENT SITUATION IN THE STATISTICAL THEORY OF DIELECTRICS, AS FAR AS LINEAR EFFECTS IN THE FIELD ARE CONCERNED: THEORY OF THE STATIC DIELECTRIC CONSTANT, AND OF THE DYNAMIC (FREQUENTLY DEPENDENT) DIELECTRIC FUNCTION.**

521681A*LEE, R.W.*RADIO-WAVE PROPAGATION PATH*CONTRACT AFLU (628)-5054*NO #*DEC 1967*AD-669 101*THIS IS THE SECOND HALF OF A REPORT ON MEASUREMENT OF ATMOSPHERIC TURBULENCE AT 35 GHZ, OVER A 28 KM LINE-OF-SIGHT PATH WITH A 2800 - LAMBDA, 9 ELEMENT RECEIVING ARRAY. BOTH THE MEASURED PHASE STRUCTURE FUNCTION AND MEASURED AMPLITUDE COVANANCE ARE COMPARED WITH THEORETICAL MODELS OF ATMOSPHERIC STRUC-TURE INVOLVING A SPECTRAL DENSITY TO SOME POWER (-11/3, IN THE CASE OF THE KOLMOGOROV SPECTRUM) OF THE TURBULENCE

WAVENUMBER.**
9436419*AFSAR, M.N.; HASTED, J.B.; ZAFAR, M.S.; AND CHAMBER-
LAIN, J.*ABSORPTION BANDS IN LIQUID CHLOROFORM AND BROMO-
FORM*NO #*CHEMICAL PHYSICS LETTERS, VOL. 31, NO. 1, 69-72*
OCT 15 1975*NO #*THE OPTICAL CONSTANTS, COMPLEX REFRACTIVE
ORDER OF LIQUID CHLOROFORM AND BROMOFORM WERE MEASURED AT
20 DEG C BY DISPERSIVE FOURIER TRANSFORM SPECTROSCOPY IN THE
WAVE NUMBER REGION 20-350 CM-1 (0.5 MM - 28.5 UM) COLE-COLE
DIAGRAMS (E"(GAMMA) VS E'(GAMMA)) ARE CALCULATED FOR BOTH
LIQUIDS FROM THE REFRACTION MEASUREMENTS.**
931641B*CHAMBERS, J.; AFSAR, M.N.; MURRAY, D.R.; PRICE, G.D.
AND ZAFAR, M.S.*SUBMILLIMETER-WAVE DIELECTRIC MEASUREMENTS
ON ABSORBING MATERIALS*NO #*IEEE TRANSACTION ON INSTRUMEN-
TATION & MEASUREMENTS, VOL. IM-23, NO. 4,. 483-487*DEC
1974*NO #*A SUMMARY IS GIVEN OF PRESENT DEVELOPMENTS ON
DISPERSIVE FOURIER TRANSFORMS & TECHNIQUES FOR THE MEASURE-
MENT OF THE FREQUENCY VARIATION OF THE COMPLEX REFRACTIVE
INDEX IN THE RANGE 100 GHZ - 9 THZ. THIS PAPER DEALS WITH
MEASUREMENTS OF THE REAL PART N(GAMMA) OF THE COMPLEX
REFRACTIVE INDEX. MATERIALS CONSIDERED ARE LIQUID CHLORO-
BENZENE, ETHANOL AND POTASSIUM BROMIDE (CRYSTAL).**
241581D*DAVIES, M.; PARDOE, G.W.F.; CHAMBERLAIN, J.; AND
GEBBIE, H.A.*SUBMILLIMETER AND MILLIMETER WAVE ABSORPTION
OF SOME POLAR AND NON-POLAR LIQUIDS MEASURED BY FOURIER
TRANSFORM SPECTROSCOPY*NO #*FARADAY SOCIETY, LONDON TRANS
ACTIONS NO. 566, VOL. 66, 273-292*FEB 1970*NO #*AN ASSESS-
MENT OF THE FOURIER TRANSFORM SPECTROMETER SHOWS ITS AD-
VANTAGES FOR APPLICATIONS TO THE MILLIMETER WAVE REGION.
REFRACTION AND ABSORPTION SPECTRUM ARE OBTAINED FROM 50 CM-1
TO 2 CM-1 (.20 MM - .5 CM) IN SOME CASES. RESULTS FOR WATER,
ANALINE, 1-4 DIOXAN, CYCLOHEXANE, DECAHYDRONAPHTHALENE,
DIMETHYL ACETYLENE (2 BUTYNE), AND 1-OCTYNE ARE REPORTED
AND CONSIDERED IN RELATION TO EARLIER MICROWAVE DIELECTRIC
DATA.**
B41141B*AFSAR, M.N.; HONIJK, D.D.; PARSCHIER, W.F.; AND
GOULON, J.*DISPERSIVE FOURIER TRANSFORM SPECTROMETRY WITH
VARIABLE THICKNESS VARIABLE-TEMPERATURE LIQUID CELLS*NO #*
IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL.
MTT-25 NO. 6, 505-511*JUNE 1977*NO #*MEASUREMENTS OF THE
POWER ABSORPTION COEFFICIENT AND INDEX OF REFRACTION WERE
MADE ON GERMANIUM AND LIQUID CHLOROBENZENE AT 25 DEG C
FOR RADIATION OF WAVE NUMBER 20 CM-2 TO 180 CM-1 (500 UM -
55.5 UM) USING ROLLIN AND G LAY DETECTORS. THE LIQUID CELL
IS PLACED IN FRONT OF ONE OF THE MIRRORS OF THE MICHELSON
INTERFEROMETER.**
921582F*KEATZE, U.*DIELECTRIC RELAXATION IN AQUEOUS SOLUTIONS
OF POLYVINYLPYRROLIDONE*NO #*ADVANCES IN MOLECULAR RELAXA-
TION PROCESSES 7, 71-85*1975*NO #*THE COMPLEX DIELECTRIC
CONSTANT OF AQUEOUS SOLUTIONS OF POLYVINYLPYRROLIDONE
(SOLUTE CONCENTRATIONS C BETWEEN 1 AND 5.5 MOL L-1) AND 1-ETHYL
-2-PYRROLIDONE (C-5.5 MOL L-1) HAS BEEN MEASURED AS A

FUNCTION OF FREQENCY BETWEEN 50 MHZ AND 70 GHZ AT 25 C.
PROCEEDING FROM AN ANALYSIS OF THE FREQUENCY DEPENDENCE
OF THE PERMITTIVITY. THE EXTRAPOLATED HIGH FREQUENCY

PERMITTIVITY OF THE SOLUTIONS, THE EXTRAPOLATED LOW FREQUENCY PERMITTIVITY OF THE SOLVENT WATER AND THE RE- ORIENTATION TIME OF THE WATER MOLECULES INFLUENCED BY THE SOLUTE PARTICLE ARE DISCUSSED. EXPERIMENTAL METHODS OF MEASUREMENTS ARE ALSO DISCUSSED.**

921583B*STAMPER, ULRICH*DIELECTRIC ABSORPTION OF LIQUID NORMAL CELKANES IN THE MICROWAVE AND FAR INFRARED REGIONS *NO #*ADVANCES IN MOLECULAR RELAXATION PROCESSES 7, 189-208*1975*NO #*MEASUREMENTS WERE MADE OF THE COMPLEX PERMIT- TIVITY E=E'(1-GTAN DELTA) AT VARIOUS TEMPERATURES AT FRE- QUENCIES GAMMA OF 28, 38, 50, 56, 70, AND 138 GHZ IN THE MICROWAVE REGION WITH AN OVERSIZED CAVITY RESONATOR. IN THE FAR IR, TWO BECKMAN FOURIER SPECTROMETERS WERE USED; THE FREQUENCY RANGE FROM 600 TO 1500 GHZ WAS SCANNED BY A LAMELLAR GRATERY TYPE LR 100. FOR THE 2000-6000 GHZ REGION, A MICHELSON INTERFEROMETER WAS USED.**

921151E*JONES, M.C.*FAR INFRARED ABSORPTION IN LIQUIFIED BASES*NO #*NBS TECH NOTE 390*APRIL 1970*N70-29103*JONES MEASURED THE FAR IR ABSORPTION SPECTRUM OF THE LIQUIDS HYDROGEN (3-PARA CONCENTRATIONS), NITROGEN, OXYGEN, CARBON MONOXIDE, METHANE AND ARGON IN THE WAVE NUMBER RANGE 20- 250 CM-1 (40-500 UM); ADDITIONALLY, DATA FOR LIQUID HYDROGEN ARE GIVEN AT WAVE NUMBERS UP TO 600 CM-1 (16.7 UM). THE RESULTS ARE DISCUSSED IN TERMS OF THE INDUCED DIPOLE, AND IN THE USE OF CARBON MONOXIDE, THE PERMANENT FIPOLE. A LITTROW MOUNTED F/28 GRATING MONO- CHROMETER WAS USED A GOLAY CELL WAS USED AS A DETECTOR. CRYSTAL QUARTZ WAS USED AS WINDOWS ON MOST OF THE MEASURE- MENTS; A POLYETHELENE WINDOW WAS FINALLY MADE TO WORK ON THE EXPERIMENT ON LIQUID HYDROGEN.**

B11581I*NO #*DIELECTRIC PROPERTIES OF BASALT POWDERS*NASA- CONTRACT NASB-25119/A D LITTLE CO.*NO #*JUNE 1, 1970* N70-32144*DIELECTRIC CONSTANTS OF CRUSHED BASALT POWDERS WERE MEASURED AT X BAND (3.2 CM) AND K BAND (1.2 CM) FOR POWDERS SIZED INTO 3 GROUPS (0-37 UM, 37-63 UM, AND 63- 125 UM) IN DIAMETER. MEASUREMENT OF THE ATTENUATION FOR EACH SAMPLE SIZE RANGE WERE MADE. AND THE DIELECTRIC CONSTANT E', AND THE LOSS TANGENT DELTA WERE CALCULATED. THE MEASUREMENTS WERE PERFORMED IN A DRY NITROGEN ENVIRON- MENT AT ROOM TEMPERATURE. THE DIELECTRIC CONSTANT RANGED FROM 1.6 TO 3.3. E', THE RED PART OF THE DIELECTRIC CONSTANT, INCREASED REGULARLY WITH INCREASING DENSITY. THERE WAS NO SIGNIFICANT DIFFERENCE BETWEEN THE RESULTS OF X AND K BAND MEASUREMENTS. THE DIELECTRIC CONSTANT IS INDEPENDENT OF PARTICLE SIZE. TAN DELTA INCREASED WITH INCREASING DENSITY; THERE WAS APPARENTLY NO DIFFERENCE IN DELTA FROM X BAND TO K BAND, OR DID IT VARY WITH PARTICLE SIZE.**

941141B*FLEMING, J.W. AND NEILL, G.F.*FAR-SPHERICAL ROTATIONAL SPECTRA OF SOME FREONS: CHLOROTRIFLUOROMETHANE, DICHLORO- DIFLUOROMETHANE AND TRICHLOROFLUOROMETHANE*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY 59, 493-501*1976*NO #*THE FAR I.R. ROTATIONAL SPECTRUM OF THESE FREONS HAVE BEEN OBSERVED WITH A FOURIER TRANSFORM SPECTROMETER IN THE REGION 10-40 CM-1 AT A RESOLUTION OF .07 CM-1. THIS STUDY WAS DONE BECAUSE

OF THE CONCERN ABOUT POSSIBLE BUILDUP OF A CONCENTRATION OF THESE FREONS IN THE TROPHOSPHERE AND LOWER STRATOSPHERE AS THEY CONTINUE TO BE RELEASED AT GROUND LEVEL IN INCREASING QUANTITIES.**

C325A1A*NORMAN, CHARLES S.; SCHWARTZ, JACK; LINZ, ARTHUR*LEGEND FIELD MM MASER*MELHOUS CO., AFCRL-66-357* AF 191628-4006*APR 1966*AD-637 683*THIS IS A FINAL REPORT ON CONTRACT WORK DEALING WITH THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE PROPERTIES OF FERROELECTRIC MATERIALS LEADING TO THE DEVELOPMENT OF MATERIALS WITH THE SPECIAL PROPERTIES NECESSARY FOR THE OPERATION OF A LEGARD FIELD MASER IN THE MM RANGE. MEASUREMENTS OF LIGARD FIELDS NEAR GROUND STATE CROSS OVERS BY OPTICAL AND MICROWAVE SPECTROSCOPY ARE DISCUSSED AS WELL AS MAGNETOMETER METHODS.**

C11581F*HORTON, J.B. AND DONALDSON, M.R.*INVESTIGATION OF LARGE SIGNAL MICROWAVE EFFECTS IN FERROELECTRIC MATERIALS, FINALF REPORT, 1 JULY 1963 - 31 JAN 1966*SPERRY MICROWAVE, CONTRACT NO. DA36-039-AMC-03240(E)*MAR 1966*AD-634 524* THEORY AND MEASUREMENT TECHNIQUES FOR OBTAINING THE DIELECTRIC CONSTANT AND LOSS TANGENTS FOR FERROELECTRIC MATERIALS AT LOW FREQUENCIES, AND IN THE MICROWAVE BAND, 1 GHZ - 35 GHZ ARE GIVEN, AND SOME RESULTS ARE INCLUDED. ALSO, RESULTS OF INVESTIGATIONS OF METHODS OF PREPARING POLYCRYSTALLINE CERAMIC MATERIALS FOR MICROWAVE FREQUENCY USE IS REPORTED. METHODS OF INVESTIGATING THE NON-LINEAR PROPERTIES OF FERROELECTRIC MATERIALS BIASED IN THE PARAELECTRIC REGION ARE INCLUDED. GENERAL APPLICATION OF FERROELECTRIC MATERIALS FOR MICROWAVE COMPONENTS IS DISCUSSED.**

523171D*ALTSHULER, EDWARD E.*EARTH-TO-SPACE COMMUNICATIONS AT MM WAVELENGTH*AFCRL-65-566*NO #*AUG 1965*AD-621 942* A PROGRAM TO INVESTIGATE THE FEASIBILITY OF EARTH-SPACE COMMUNICATION CHANNELS INTHE MM WAVE REGION IS PRESENTED. THE THEORY OF ATMOSPHERIC ATTENUATION DUE TO ABSORPTION, SCATTERING AND REFRACTION PROPENTION PROPERTIES OF ATMO-SPHERIC GASSES, CLOUDS AND PRECIPITATION. CURVES OF TOTAL ATMOSPHERIC ATTENUATION AND NOISE LEVEL AS A FUNCTIONOF METEOROLOGICAL PARAMETERS AND ANTENNAE DEVIATION ANGLE ARE ALSO PRESENTED. A SERIES OF EXPERIMENTS DESIGNED TO OBTAIN AS MUCH INFORMATION AS POSSIBLE ON THE LIMITATIONS IMPOSED BY THE ATMOSPHERE ON MM WAVE PROPAGATION IS PRE-SENTED.**

933581G*CHANTRY, G.W.*DIELECTRIC MEASUREMENTS IN THE SUBMILLI-METER REGION AND A SUGGESTED INTERPRETATION OF THE POLEY ABSORPTION*NO #*IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. MTT-25, NO. 6, 496-500*JUNE 1977*NO #* MODEN ACTIVITY IN THE FIELD OF EXTRA HIGH FREQUENCY DIELEC-TRIC MEASUREMENTS ON POLAR LIQUIDS IS BRIEFLY REVIEWED AND THE MEANS FOR CARRYING THEM OUT BRIEFLY DESCRIBED. IT IS NOW POSSIBLE TO DETERMINE THE COMPLEX PERMITTIVITY (AND HENCE, THE COMPLEX REFRACTIVE INDEX) OVER THE RANGE 10 TO 8TH TO 10 TO 13TH HZ TO AN ABSOLUTE PRECISION OF 1% AND IS, THEREFORE, WORTHWHILE TO RE-EXAMINE THE LIQUID LATTIMER THEORY WHICH WAS PUT FORWARD SOME TIME AGO AS AN EXPLANATION FOR THE ADDITIONAL POLAY ABSORPTION. THIS

THEORY IS FOUND TO GIVE A GOOD ACCOUNT OF THE ABSORPTION SPECTRUM OF LIQUID CHLOROBENZENE ON THE UWAVE, MM AND SUB MM REGIONS.**

6217619*GRAULING, C.H.*THE 60 GHZ RADIOMETER LOCAL VERTICAL SENSOR EXPERIMENT*CONTRACT NAS 1-10131*NO #*APR 1973* N73-22396*THIS FINAL REPORT SUMMARIZES THE MAJOR RESULTS. THE EXPERIMENT CONCEPT INVOLVES USE OF MM WAVE RADIATION FROM THE ATMOSPHERIC OXYGEN TO PROVIDE LOCAL SENSING INFORMATION TO A SATELLITE BORNE RADIOMETER. IT WAS CONCLUDED THAT A VIABLE SENSING TECHNIQUE EXISTS, USEFUL OVER A WIDE RANGE OF ALTITUDE WITH AN ACCURACY GENERALLY ON THE ORDER OF 0.01 DEG OR BETTER.**

B217619*BASHARINOV, A.E.*MICROWAVE RADIATION CHARACTERISTICS OF DRY AND MOIST GROUND COVERS*NASW-2484*NO #*JULY 1973* N73-26153*MICROWAVE (8 MM) (RADIOMETER) MEASUREMENTS FROM SPACE CAN BE USED TO DETECT FIRES, MEASURE SOIL MOISTURE AND TEMPERATURE, MEASURE SUB-ICE SOIL TEMPERATURES AND THE THICKNESS OF ICE COVER, AS WELL AS IN THE SEARCH FOR SUB-SURFACE WATER. (RUSSIAN TRANSLATION OF A COMMUNICATION TO THE SEMINAR OF THE SOVIET-AMERICAN WORKING GROUP ON LAND RESOURCE SURVEY BY REMOTE SENSING METHODS.**

563185B*COLE, A.E., SECRETARY, LABORATORY GROUP*U.S. STANDARD ATMOSPHERE, 1976*NO #*NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION*OCT 1976*AD-A035 728*THE U.S. STANDARD ATMOSPHERE, 1976, WHICH IS A REVISION OF THE U.S. STANDARD ATMOSPHERE, 1962, WAS GENERATED UNDER THE IMPETUS OF INCREASED KNOWLEDGE OF THE UPPER ATMOSPHERE OVER THE PAST SOLAR CYCLE. ABOVE 50 KM, THIS STANDARD IS BASED ON EXTENSIVE NEW ROCKET DATA AND THEORY FOR THE MESOSPHERE AND LOWER THERMOSPHERE, AND ON THE VAST RESOURCES OF SATELLITE DATA FOR THE THERMOSPHERE REQUIRED OVER MORE THAN ONE COMPLETE SOLAR CYCLE.**

211173D*HYDE, G.*DATA ANALYSES REPORT ON ATS-F COMSAT MM WAVE PROPAGATION EXPERIMENT PART 1. (COMSAT EXPERIMENT)* NASA-CR-152449: CONTRACT #NAS5-21616*NO #*SEPT 1976* N77-19292*THE DATA ANALYSES REPORT, PART 1, DISCUSSES THE RESULTS OF THE 13/18 GHZ COMSAT PROPAGATION EXPERIMENT TO MEASURE ATTENUATION CAUSED BY HYDROMETERS ALONG SLANT PATHS FROM TRANSMITTING TERMINALS ON THE GROUND TO THE ATS-6 SATELLITE AND THE EFFECTIVENESS OF SITE DIVERSITY IN OVERCOMING THIS IMPAIRMENT. THE EXPERIMENT IS REVIEWED, CUMULATIVE RAIN RATE STATISTICS FOR THE FAYETTEVILLE AND BOSTON SITES BASED ON POINT RAINFALL DATA COLLECTED ARE PRESENTED. EXTRAPOLATIONS OF THE ATTENUATION AND POINT RAINFALL DATA ARE PRESENTED AND DISCUSSED.**

952181N*EVANS, GARETH J. AND EVANS, MYRON W.*USE OF THE MEMORY FUNCTION TO SIMULATE THE DEBYE AND POLEY ABSORPTION IN LIQUIDS*NO #*JOURNAL OF THE CHEMICAL SOCIETY OF LONDON, FARADAY TRANSACTION II, NO.7, 1169-1184*1976*NO #*A SINGLE SIMPLE EQUATION IS DERIVED TO DESCRIBE THE MOLECULAR ROTATIONAL PROCESSES GIVING RISE TO THE MICROWAVE AND FAR INFRARED ABSORPTION BANDS OF DIPOLAR MOLECULES IN THE LIQUID PHASE. THE ABSORPTION SPECTRUM OVER APPROXIMATELY 3 DECADES OF FREQUENCY IS DEDUCED BY APPROXIMATING THE ASSOCIATED ORIENTATIONAL CORRELATION FUNCTION WITH A HIERARCHY

OF RESPONSE FUNCTIONS (OR MEMORY FUNCTIONS). THESE AND THE CORRELATION FUNCTION FORM A SET OF INTEGRO-DIFFERENTIAL EQUATIONS CALLED THE MORI SERIES. BY TRUNCATING THIS AT A CERTAIN LEVEL, WITH AN EMPIRICAL FUNCTION SUCH AS A SINGLE EXPONENTIAL OF CORRELATION TIME 1/GAMMA, A SPECTRUM CAN BE CALCULATED WHICH CONTAINS EQUILIBRIUM AVERAGES PROPORTIONAL TO THE INTERMOLECULAR MEAN SQUARE TORQUE, (O(V)2), ITS DERIVATIVE (DELTA(V)2), ETC., DEPENDING ON THE LEVEL AT WHICH THE MORI SERIES IS TRUNCATED. THE FORMALISM IS TESTED WITH THE LIQUIDS CHF3, CCIF3, CBRF3, CHC2H3 AND THE NEMATOGEN MBBA, A SERIES CHOSEN TO COVER THE EXTREMES OF MOLECULAR ISOTROPY AND ANISOTROPY.**

C12761N*HOLMES, J.J.; BALANIS, C.A.; AND TRUMAN, W.M.*APPLICATION OF FOURIER TRANSFORMS FOR MICROWAVE RADIOMETRIC INVERSIONS*NO #*IEEE TRANSACTIONS ON ANTENNAS & PROPAGATION, VOL. AP-23, NO. 6, 797-806*NOV 1975*NO #*EXISTING MICROWAVE RADIOMETER TECHNOLOGY NOW PROVIDES A SUITABLE METHOD FOR REMOTE DETERMINATION OF THE OCEAN SURFACE'S ABSOLUTE BRIGHTNESS TEMPERATURE. TO EXTRACT THE BRIGHTNESS TEMPERATURE OF THE WATER FROM THE ANTENNA TEMPERATURE, AN UNSTABLE FREDHOLM INTEGRAL EQUATION OF THE FIRST KIND IS SOLVED. FOURIER TRANSFORM TECHNIQUES ARE USED TO INVERT THE INTEGRAL AFTER IT IS PLACED INTO A CROSS CORRELATION FORM. APPLICATION AND VERIFICATION OF THE METHODS TO A TWO-DIMENSIONAL MODELING OF A LABORATORY WAVE TANK SYSTEM ARE INCLUDED. THE INSTABILITY OF THE B-POSED FREDHOLM EQUATION IS EXAMINED AND A RESTORATION PROCEDURE IS INCLUDED WHICH SMOOTHS THE RESULTING OSCILLATIONS. WITH THE RECENT AVAILABILITY AND ADVANCES OF FAST FOURIER TRANSFORM (FFT) TECHNIQUES, THE METHOD PRESENTED BECOMES VERY ATTRACTIVE IN THE EVALUATION OF LARGE QUANTITIES OF DATA. ACTUAL RADIOMETRIC MEASUREMENTS OF SEA WATER ARE INSERTED USING THE RESTORATION METHOD, INCORPORATING THE ADVANTAGES OF THE FFT ALGORITHM FOR COMPUTATIONS.**

622131G*REBER, E.E.; MITCHELL, R.L.; AND CARTER, C.J.* OXYGEN ABSORPTION IN THE EARTH'S ATMOSPHERE*F04701-68-C-0200*NO #*NOV 1968*AD-680 771*AN EXTENSIVE MEASUREMENT PROGRAM DESIGNED TO MEASURE THE ATTENUATION OF E & M ENERGY IN THE O2 ABSORPTION SPECTRUM (48-72) GHZ BY THE ATMOSPHERE IS DESCRIBED. MEASUREMENTS WERE MADE UTILIZING THE SUN AS A SOURCE AT 6 DISCRETE ALTITUDES RANGING FROM SEA LEVEL TO 13.7 KM AND OVER A FREQUENCY RANGE OF 53.4 TO 56.4 GHZ. THE MORE THAN 1500 INDEPENDENT MEASUREMENTS WERE USED TO CALCULATE NEW VALUES FOR THE VAN VLECK LINE BROADENING COEFFICIENTS. ZENITH ATTENUATIONS WERE COMPUTED UTILIZING THESE NEW COEFFICIENTS OVER THE FREQUENCY RANGE 48-72 GHZ AND FOR SEVERAL ALTITUDFES FROM 0 TO 25 KM. IN ADDITION, BOTH HORIZONTAL ATTENUATION RATES AND TANGENTIAL ATTENUATION THROUGHOUT THE ATMOSPHERE HAVE BEEN COMPUTED FOR SEVERAL ALTITUDES.**

521131H*KISLYAKOV, A.G. AND INIKONOV, V.N.*AN EXPERIMENTAL STUDY OF ATMOSPHERIC ABSORPTION ON A 4.1 MM WAVE AS A FUNCTION OF THE HEIGHTS ABOVE SEA LEVEL*NO #*NO #*OCT 1968*AD-685 998*RESULTS OF MEASUREMENTS OF ZENITH ATMOSPHERIC ABSORPTION ON A 4.1 MM WAVE, CARRIED OUT AT NIRFI FROM

1960-1964 ARE GIVEN. MEASUREMENTS WERE CONDUCTED BY RADIO ASTRONOMICAL METHODS AT DIFFERENT HEIGHTS ABOVE SEA LEVEL, WHICH MADE IT POSSIBLE TO DETERMINE THE EFFECTIVE PATH FOR O2 AND WATER VAPOR OF THE ABMOSPHERE IN ABSORPTION. TOTAL ABSORPTION OF THE ATMOSPHERE FROM SEA LEVEL DURING ZENITH OBSERVATION IS GAMMA = 0.26 + 0.0065 P VAPOR, WHERE P = ABSOLUTE HUMIDITY IN THE SURFACE LAYER OF AIR. EFFECTIVE HEIGHTS OF O2 AND WATER VAPOR OF THE ATMOSPHERE ARE RESPECTIVELY (4.3 + OR - .3) KM, AND (1.75 + OR - 0.1) KM. COEFFICIENTS OF ABSORPTION OF O2 AND WATER VAPOR AT SEA LEVEL ARE (0.21 + OR - .02) AND (.13 + OR - .02) DB/KM, RESPECTIVELY.**

523133A*WINKLER, LOUIS*THE PENNSYLVANIA STATE UNIVERSITY RADIO ASTRONOMY OBSERVATOR*DA-18-001-AMC-905(X)*NO #*NOV 1968* AD-687 391*THE PURPOSE OF THE WORK RELATING TO THIS REPORT IS TO STUDY THE PROPAGATION CHARACTERISTICS OF MM WAVES IN THE EARTH'S ATMOSPHERE. ONE METHOD USED TO ACCOMPLISH THIS WAS TO MAKE MEASUREMENT OF THE SUN AND ATMOSPHERE TOGETHER, AND THE ATMOSPHERE ALONE. THESE MEASUREMENTS WERE MADE WITH A 36 GHZ RADIOMETFR. OTHER METHODS WERE TO REDUCE AND ANALYZE DATA SUPPLIED BY THE TECHNICAL MONITOR AND DEVELOP SOME RELATED THEORETICAL IDEAS.**

922581B*GIESE, K.*CORRELATION ANALYSIS OF EXPERIMENTAL PER- MITTIVITY DATA*NO #*ADVAN. IN MOLECULAR RELAXATION PROCESSES, 7, 157-166*1975*NO #*THE AUTO-CORRELATION OF FUNCTION PHI NIN(GAMMA) OF THE RELAXATION TIME DISTRIBUTION FUNCTION GAMMA(R) IS OBTAINED FROM THE AUTO- AND CROSS- CORRELATION OF REAL AND IMAGINARY PARTS OF THE PERMITTIVITY DATA ARE SUBJECT TO EXPERIMENT ERROR. THE SPECTRUM OF THE AUTO-CORRELATION FUNCTION APPEARS TO BE MOST SUITABLE FOR THE DETERMINATION OF THE DISTRIBUTION FUNCTION H(R). IT IS NECESSARY TO OBTAIN ADDITIONAL INFORMATION BY EVAL- UATING THE LOWER ORDER MOMENTS OF THE DISTRIBUTION FUNCTION.**

D311651C*MENDONCA, J.*MILLIMETER WAVE POLAR METERS AND THE COTTON-MOUTON EFFECT IN PLASMAS*NO #*NO #*DEC 1972* EUR-CEA-FC-675*THIS PHD THESIS IS A STUDY OF THE COTTON- MOUTON EFFECT ON A PLASMA OF 2 AND 4 MM WAVELENGTHS. ORDINARY TURNSTILE CURVE GUIDE FUNCTIONS AT 2-3 CM ARE NOT EASILY SCALABLE FOR 2-4 MM USE; THEY ARE DESIRED AS POLARIZATION ANALYZING ELEMENTS. TITLE OF CHAPTERS OF THIS THEME ARE: 1) CERTAIN EQUIVALENT SCHEMES. 2) SMALL DIMENSIONED GUIDE POLARIZER. 3) MEASUREMENTS PROCEDURE. 4) POLARIZATION IN AN INHOMOGENEOUS MAGNET PLASMA. 5) MEASUREMENT OF THE COTTON MOUTON EFFECTS ON A PLASMA (AT .337, 2, AND 4 MM).**

212561I*PORTER, RONALD A. AND HO, PING-TONY*MICROWAVE RADIO- METRIC SENSING OF SURFACE TEMPERATURE AND WIND SPEED FROM SEASAT*CONTRACT # 6-35217*NO #*FEB 1977*PB-270 323*A COM- PREHENSIVE STUDY HAD BEEN PERFORMED TO DETERMINE THE ACCURACY WITH WHICH SEA SURFACE TEMPERATURES AND WIND SPEEDS CAN BE DERIVED FROM BRIGHTNESS TEMPERATURES TO BE SENSED BY THE SEASAT SMMR MICROWAVE RADIOMETER (APPARENTLY 6.6, 10.4 AND 18 GHZ). THIS WORK WAS BASED ON THE USE OF A 2-SCALE OCEAN ROUGHNESS MODEL. AN INSTRU- MENT 2-SECTION OCEAN FOAM MODEL, CONSISTING OF WHITE CAPS

AND FROM STREAKS WAS APPLIED TO THE WORK PERFORMED ON THIS STUDY. 11 WAVE FREQUENCIES WERE USED IN THIS STUDY, TOGETHER WITH 10 ATMOSPHERE MODELS COVERING SUB-POLAR, MID-LATITUDE AND TROPICAL REGIONS. A COMPUTATION WAS PERFORMED AT A SINGLE ANTENNAE BEAM INCIDENCE ANGLE OF 48.9 DEG. THERE IS COMPLEX DIELECTRIC CONSTANT DATA ON SEA WATER, SEA FORM, AND EMISSIVITY OF WATER AND FOAM, FOR FREQUENCIES FROM 5 TO 38 GHZ.**

C235519*DAGAI, MICHEL*MEASUREMENT OF THE PERMITTIVITY OF AS LIQUID DIELECTRIC: DOCTOR OF SCIENCE THESIS, SACLAY. (U)(IN FRENCH)*CEA-B2993*NO #*1966*PB-173 395*WE PLAN TO STUDY THE ELEMENTS NECESSARY TO REALIZE TWO TYPES OF INTERFEROMETER: A) INTERFEROMETER WITH TWO SEPARATED WAVE PATHS, UTILIZING A TRANSMISSION CELL AT AMBIENT TEMPERATURE. B) MICHELSON INTERFEROMETER, UTILIZING A REFLECTION CELL, WITH VARIABLE TEMPERATURE: WAVE BAND COVERED: 2 MM - 8.6 MM.**

D22661C*ETIEVANT, C.*APPLICATION OF MICROWAVES AND FAR INFRA-RED TO THE PROBLEMS OF DIAGNOSTICS IN RESEARCH ON CON-TROLLED FUSION (IN FRENCH)*NO #*ASSOCIATION EURATOM-CEA SUR LA FUSION*21 MAY 1973*CEA-CONF-2313*CONTROLLER FUSION PRESENTS US WITH SEVERAL DIAGNOSTIC PROBLEMS. ONE CON-SIDERS SUCCESSIVELY: MEASUREMENT PLASMA DENSITIES INTER-FEROMETRICALLY, THE DETERMINATION OF DENSITY PROFILES BY MATTER FOULED INTERFEROMETRY AND BY REFLECTOMETRY, THE STUDY OF TURBULENCE BY DIFFUSION OF MICROWAVE, THE MEASUREMENT OF COMPONENTS OF MAGNETIC FIELD BY FORSDAY ROTATION AND BY A METHOD EXPLOITING THE NON-LINEAR PROPERTIES OF PLASMAS (WAVELENGTH COVERAGE: 0.3-4 MM).**

943561E*LEROY, Y.; CONSTANT, E.; ABBAR, C.; AND DESPLASIQUES, P.*CORRELATION, RELAXATION AND ULTRAHERTZIAN ABSORPTION IN LIQUIDS*NO #*ADVANCE MOL. RELAXATION PROCESSES, 1, 273-307*1967-68*NO #*THIS IS AN EXPERIMENMTAL AND THEORETI-CAL STUDY OF ABSORPTION OF RADIO WAVES, CM--SUB MM IN LENGTH IN POLAR LIQUIDS WITH SIMPLE RIGID MOLECULES. IN THE FIRST PART, EXPERIMENTAL RESULTS ARE SUMMED UP. MOLECULES STUDIED ARE PLANAR OR "SYMMETRIC TOP." A FINAL ANALYSIS OF THESE DATA PROVIDES EVIDENCE OF TWO NEW PHENOMENA WHICH HAVE NOT BEEN SYSTEMATICALLY STUDIED. IN THE SECOND PART, WE TRY TO INTERPRET THEORETICAL RESULTS OBTAINED FROM THE CORRELATION FUNCTION CONCEPT, SUBSTANCES STUDIED WERE TRICHLORETHANE-HEXANE AND TRICHLOROMETHANES, AND METHYL PROPYL CHLORIDE.**

213111K*GODARD, S.L.*PROPAGATION OF CENTIMETER AND MILLIMETER WAVELENGTHS THROUGH PRECIPITATION*NO #*IEEE TRANSACTIONS ON ANTENNAS & PROPAGATION, VOL. 18, NO. 4, 530-534*JULY 1970*NO #*FROM THEORETICAL CONSIDERATIONS, IT IS POSSIBLE TO CALCULATE ATTENUATION THROUGH RAIN AT SEVERAL WAVE-LENTHS. IT IS SHOWN THAT ATTENUATION IS A LINEAR FUNCTION OF RAIN RATE FOR A 0.86-CM WAVELENGTH. THIS PROPERTY IS INDEPENDENT OF THE DISTRIBUTION SPECTRA OF DROP RADIUS WITHIN A TEN-PERCENT PRECISION. THIS LATER PROPERTY HAS BEEN TESTED EXPERIMENTALLY IN TWO DIFFERENT WAYS. 1) MEASURE-1) MEASUREMENTS THROUGH RAIN HAVE BEEN MADE WITH A RADAR AT 0.86 CM. RESULTS ARE REPORTED. THEY SHOW QUITE IMPOR-

TANT DIFFERENCES BETWEEN THEORETICAL AND EXPERIMENTAL RESULTS. 2) EXPERIMENTS HAVE BEEN CONDUCTED IN RAINFALL TO MEASURE FALL SPEEDS AND DIAMETER SPECTRA OF DROPS. THER APPARATUS USED FOR THIS PURPOSE IS BRIEFLY DESCRIBED. WITH THE RESULTS OBTAINED IT IS POSSIBLE TO CALCULATE THE PROPAGATION PROPERTIES OF RAINFALL AT SEVERAL WAVELENGTHS, PARTICULARLY AT 0.86 CM.**

913561G*CROSSLEY, J; TAY, S.P.; AND WALKER, S.*EVALUATION OF RELAXATION PARAMETERS FROM DIELECTRIC DATA*NO #*ADVAN. IN MOLECULAR RELAXATION PROCESSES, VOL. 6, 69-78*1974* NO #*THE PERMITTIVITY E' AND THE LOSS FACTOR E" OF 14 SOLUTIONS (HYDROCARBON) HAVE BEEN MEASURED AT 9 ANGULAR FREQUENCIES W (.002-141 GHZ). EACH SOLUTION CONSISTS OF TWO POLAR SOLUTES WITH KNOWN RELAXATION TIMES (T1 AND T2 WITH WEIGHT FACTORS C1 AND C2) IN EXCESS OF A NON-POLAR SOLVENT. FROM THE EXPERIMENTAL DATA FOR EACH SOLUTION, THE MEAN RELAXATION TIMES TO AND THE DISTRIBUTION PARAMETER ALPHA HAS BEEN EVALUATED BY 6 DIFFERENT METHODS. FOR 13 OF THESE CASES, THE MEAN RELAXATION TIME TO EXP HAS BEEN COMPARED WITH ONES DEDUCED FROM EQUATIONS RELATING T1, T2 AND C1 WITH TO THER. ON THE WHOLE, THE AGREEMENT BETWEEN THE 6 DIFFERENT PROCEDURES FOR EVALUATING TO EXP IS GOOD.**

B616619*LINDBERG, JAMES D. AND GILLESPIE, JAMES B.*RELATIONSHIP BETWEEN PARTICLE SIZE AND IMAGINARY REFRACTIVE INDEX IN ATMOSPHERIC DUST*NO #*APPLIED OPTICS, VOL 16, NO. 10, 2628-2630*OCT 1977*NO #*THIS ARTICLE DISCUSSES DUST SAMPLES COLLECTED AT WHITE SANDS MISSILE RANGE, FROM LAMBDA - 0.3 UM TO LAMBDA - 1.7 UM. COMPONENTS OF THIS DUST WERE CLAYS, QUARTZ, COLATE, GYPSUM, AMMONIUM SULFATE, AND CARBON. SIZE DISTRIBUTIONS OF THE DUST ARE GIVEN AND DISCUSSED.**

C43141F*GENZEL, L. AND SAKIR, K.*INTERFEROMETRY FROM 1950 TO THE PRESENT*NO #*JOURNAL OPTICAL SOC. AM., VOL. 67, NO. 7, 871-874*NO #*JULY 1977*NO #*THIS PAPER REVIEWS THE HISTORY OF THE IMPORTANT ASPECTS AND THE DEVELOPMENT OF FAR IR FOURIER TRANSFORM SPECTROSCOPY AND FOBRY PEROT INTERFEROMETRY FROM 1950 TO THE PRESENT. MOST OF THE FUNDAMENTALS OF FOURIER SPECTROSCOPY WERE WORKED OUT IN THE PERIOD FROM 1951-1961 AFTER THE REALIZATION OF THE MULTIPLEX ADVANTAGE. THE FOLLOWING PERIOD FROM 1962 - PRESENT BROUGHT NEW INSTRUMENTAL INNOVATIONS AND REFINEMENTS AND THE STAGE OF GENERAL USE. FOBRY-PERST INTERFEROMETRY BECAME POSSIBLE IN THE FAR IR SINCE METAL MESH WAS FOUND TO BE THE IDEAL REFLECTOR FOR THE INTERFEROMETER. THIS KIND OF INTERFEROMETRY IS NOW MAINLY AND INCREASINGLY USED IN CONNECTION WITH FAR IR LASER RESEARCH.**

5411819*HARRIES, J.E.*SUB MM WAVE SPECTROSCOPY OF THE ATMOSPHERE*NO #*J. OPT. SOC. AM. VOL. 6, NO. 7, 880-894*NO #*JULY 1977*NO #*A SURVEY OF THE HISTORY AND DEVELOPMENT OF SUB MM ATMOSPHERIC SPECTROSCOPY IS PRESENTED UP FRONT INCLUDING THE MOST RECENT ACTIVITIES AND PROGRESS IN THE FIELD. OUR CURRENT UNDERSTANDING OF THE DETAILS OF THE SPECTRUM AND THE INFORMATION IT CAN PROVIDE IS DISCUSSED, AND THE PAPER CONCLUDES WITH SOME SUGGESTIONS ABOUT

FUTURE DEVELOPMENTS ON THE SUBJECT. 80 REFS.**
512171D*ZHEVSKIN, S.A. AND NAUMOV, A.P.*PROPAGATION OF CENTIMETER, MILLIMETER, AND SUB MILLIMETER*NO #*NO #*SEPT 1969*AD-694 411*WORKING FROM EXTENSIVE BIBLIOGRAPHY (199 ENTRIES), THE AUTHORS REVIEW THE PRESENT STOCK OF KNOWLEDGE OF PROPAGATION OF MICROWAVES IN THE EARTH'S ATMOSPHERE. THE EFFECT OF WATER VAPOR DIMER, AND DONOMERS AS WELL AS O2 ARE EXAMINED AS THEY CONTRIBUTE TO THE TOTAL ABSORPTION COEFFICIENT. THREE FORMS OF THE SPECTRAL LINES ARE CONTRASTED; 1) BY LORENTZ, 2) VAN VLECK AND WEISHOPF, AND 3) A FORM OBTAINED FROM A SOLUTION OF THE KINETIC EQUATION. NATURAL ATMOSPHERIC WAVEGUIDES ARE DISCUSSED BRIEFLY INDICATING WHY IT IS IMPRACTICAL TO USE THEM FOR COMMUNICATIONS.**
622181A*REBER, E.E.; MITCHELL, R.L.; AND CARTER, C.J.*ATTENUATION OF THE 5-MM WAVELENGTH BAND IN A VARIABLE ATMOSPHERE*NO #*NO #*JULY 1969*AD-694 510*EFFECTS OF ATMOSPHERIC CHANGES ON ATTENUATION IN THE ATMOSPHERE FOR THE 5-MM WAVELENGTH REGION OF THE E & M SPECTRUM (48-72 GHZ). ATTENUATION VS FREQUENCY AND ALTITUDE FOR VERTICAL TRANSMISSION THROUGH THE ATMOSPHERE, CAUSED BY O2 ABSORPTION, ARE TABULATED FOR GEOGRAPHICAL AND SEASONAL MODEL ATMOSPHERES. THE ATTENUATION EFFECTS OF ATMOSPHERIC WATER FORMATIONS ARE DISCUSSED AND COMPARED TO O2 ATTENUATION.**
212411A*KRASYUK, N.P. AND IROZENBERG, V.I.*RADAR CHARACTERISTICS OF PRECIPITATION OF DIFFERENT NATURE*NO #*NO #*OCT 1969*AD-700 401*THE SPECIFIC EFFECTIVE AREA OF RETROGRADE SCATTERING OF AND ATTENUATION FACTOR OF RADIO WAVES IN THE CM MM BAND, IN RAINFALLS OF VARIOUS ORIGIN WITH VARIOUS LEVELS OF RAINDROP SIZE DISTRIBUTIONS, AT VARIOUS TEMPERATURES AND RAIN IN FORESTS WERE CALCULATED. THIS QUANTITATIVE DATA ON THE ATTENUATING AND REFLECTING EFFECT OF RAIN ON THE OPERATION OF ELECTRONIC EQUIPMENT IN THE CM AND MM RANGE.**
211173A*CRANE, ROBERT K.*RAIN ATTENUATION AT MILLIMETER WAVELENGTHS*AF19(628)-5167*NO #*1968*AD-707 813*THE MAJOR PROPAGATION PROBLEM CONFRONTING THE USE OF MM WAVES FOR LINE-OF-SIGHT COMMUNICATION LINKS OPERATING THROUGH THE ATMOSPHERE IN HYDROMETER SCATTERING. RAIN, HAIL, SLEET, SNOW, AND FOG ALL CAN CAUSE SEVERE ATTENUATION AT MM WAVELENGTHS. THE PROBLEM OF HYDROMETER SCATTERING REPORTED IN THE LITERATURE TEND TO SUPPORT THE CONCLUSIONS THAT CURRENT THEORY IS NOT SUFFICIENT TO ADEQUATELY PREDICT ATTENUATION.**
5226838*ISHIMARU, A.*PROPAGATION AND RECEPTION OF PARTIALLY COHERENT WAVES IN RANDOM MEDIA*CONTRACT #F19628-69-C-0123*NO #*DEC 1971*AD-743 833*THE FINAL REPORT GIVES A SUMMARY OF ALL THE WORK COMPLETED AND UNDER WAY UNDER THIS CONTRACT COVERING THE PERIOD FROM DEC. 1968 TO DEC. 1971. THE WORK COVERS A BROAD SPECTRUM INCLUDING TEMPORAL FREQUENCY SPECTRUM, FOCUSED BEAMS, REMOTE PROBING, MULTIPLE SCATTERING EFFECTS, AND RAIN ATTENUATION.**
621131E*REBER, E.E.*ABSORPTION OF THE 4- TO 6-MM WAVELENGTH BAND IN THE ATMOSPHERE*CONTRACT F04701-71-C-0172*NO #*MAR 1972*AD-745 951*THE ANALYSIS OF AN EXTENSIVE SERIES

OF ZENITH ATTENUATION MEASUREMENTS OF THE ATMOSPHERE ON BOTH SIDES OF THE OXYGEN ABSORPTION SPECTRUM (48-72 GHZ) ELUCIDATES THE ABSORPTION CHARACTERISTICS OF THE 4 TO 6 MM WAVELENGTH BAND. WITH THE SUN AS A SOURCE, ZENITH ATTENUATION MEASUREMENTS WERE MADE AND USED AS A FUNCTION OF THE PRECIPITABLE WATER CONTENT OF THE ATMOSPHERE TO DETERMINE THE ZENITH ATTENUATION COEFFICIENTS OF PRECIPITABLE WATER. FROM THESE COEFFICIENT AND MEASUREMENTS OF THE TOTAL PRECIPITABLE WATER CONTENT IN THE ATMOSPHERE, THE OXYGEN COMPONENTS OF THE ZENITH ATTENUATION WERE DETERMINED.**

C21171A*COHN, MARVIN AND LITTLEPAGE, ROBERT S.*IMPLICATIONS OF MILLIMETER WAVE RESEARCH AND TECHNOLOGY ON NAVAL PROBLEMS*N00014-77-C-0166*NO #*JAN 1967*AD-813 462*THIS TECHNICAL REPORT CONTAINS A SURVEY AND A CRITICAL ANALYSIS OF THE EXISTING AND PROJECTED MM WAVELENGTH STATE OF THE ART. SPECIFIC AREAS TREATED ARE PROPAGATION EFFECTS, ANTENNAE, COMPONENTS, POWER SOURCES, AND RECEIVER TECHNIQUES. AREAS WHERE FURTHER RESEARCH AND DEVELOPMENT WOULD RESULT IN INCREASED PERFORMANCE HAVE BEEN POINTED OUT.**

C13171C*KEELTY, J.M. AND CRANE, R.A.*MILLIMETER INVESTIGATIONS, VOL. 5. LISTINGS OF DETAILED RESULTS, PROJECT MALLARD* CONTRACT PG 727001-1*NO #*JAN 1969*AD-857 436*THIS VOLUME CONTAINS SAMPLES OF THE COMPUTER ANALYSIS OF VARIOUS PARAMETERS SALIENT TO THE DESCRIPTION OF SYSTEM PERFORMANCE. THE VOLUME BEGINS WITH A DESCRIPTION OF THE STRUCTURE OF THE COMPUTER PROGRAMS AND A SECTION EXPLAINING THE MEANING OF SAMPLE PRINTOUTS. PRINT OUTS DETAILING PRECIPITATION RATES, ERROR-RUN DATA, AND SIGNAL STRENGTH VARIATIONS FOR VARIOUS METEOROLOGICAL CONDITIONS AND A SECTION DISCUSSINGTHE RESULTS OF A HELICOPTER TEST MAKE-UP THE REMAINDER OF THE REPORT.**

513183A*STEELE, F.K. AND VAN HORN, S.F.*A BIBLIOGRAPHY OF RECENT WORK ON PROPAGATION IN THE RADIO SPECTRUM FROM 10 TO 100 GHZ*NO #*NO #*JAN 1975*COM-75-10781*REFERENCES ARE PRESENTED ON THE SUBJECT OF RECENT (1971 TO MID 1974) WORK ON RADIO PROPAGATION THROUGH THE ATMOSPHERE AT FREQUENCIES FROM 10 GHZ TO 100 GHZ. THE REFERENCES ARE SEPARATED INTO SIX MAJOR CATEGORIES COVERING PROPAGATION THROUGH PRECIPITATION, MULTIPATH PROPAGATION, THROUGH NON-TURBULENT CLEARANCE, TURBULENT-CLEAR ATMOSPHERES, MEASUREMENTS/DATA, AND A GENERAL CATEGORY.**

621681D*LIEBE, HANS J.*A PRESSURE-SCANNING REFRACTION SPECTROMETER FOR ATMOSPHERIC GAS STUDIES AT MILLIMETER WAVELENGTHS*NO #*NO #*APR 1974*COM-75-10808*A DIFFERENTIAL REFRACTION SPECTROMETER WAS DEVELOPED CAPABLE OF MEASURING UNDER SIMULATED ATMOSPHERIC CONDITIONS MOLECULAR EHF PROPAGATION FACTORS, ESPECIALLY THE INTENSITY DISTRIBUTION OF THE OXYGEN UWAVE SPECTRUM (O2-MS). DISPERSION AND ATTENUATION PRESSURE PROFILES ARE MEASURED BETWEEN 10-3 AND 103 TORR. THE SENSITIVITIES ARE BETTER THAN 1 PART ON 10 THE 9TH AND 0.01 DB/KM. THE MULTI-LINE (APPROX 43) STRUCTURE OF THE O2 MS ABOUT 60 GHZ COMPLICATES THE DATA ANALYSIS. SPECIAL DIAGNOSTICS EVOLVED FROM THE DATA

FOR DEDUCING SPECTROSCOPIC PARAMETERS.**
623171D*LIEBE, HANS J.*STUDIES OF OXYGEN AND WATER VAPOR MICROWAVE SPECTRA UNDER SIMULATED ATMOSPHERIC CONDITIONS* NASA-AAFIL58,506; NOAA-NESS5-13155*NO #*JUNE 1975*COM-75-11096*ATMOSPHERIC RADIO WAVE PROPAGATION IN THE 40-140 GHZ BAND IS INFLUENCED BY THE UWAVE SPECTRUM OF O2 AND WATER VAPOR. THIS REPORT TREATS THE COMPLIMENTARY SIDES OF THE CONTROLLED LABORATORY EXPERIMENTS AND COMPUTER ANALYSIS FOR PROVIDING MOLECULAR TRANSFER CHARACTERISTICS. A PRESSURE SCANNING DIFFERENTIAL REFRACTOMETER WAS OPERATED AT FIXED FREQUENCIES BETWEEN 58 AND 61 GHZ. THE VARIABILITY OF THE O2 AND H2O SPECTRA WITH FREQUENCY, PRESSURE, TEMPERATURE, AND MAGNETIC FIELD STRENGTH WAS STUDIED UNDER CONDITIONS WHICH OCCUR IN THE ATMOSPHERE.**
511181A*ZHEVAKIN, S.A.*PROPAGATION AND ABSORPTION OF RADIO WAVES IN THE ATMOSPHERE AND TROPOSPHERE*NO #*NO #*AUG 1968* JPRS 46311*THIS PUBLICATION CONTAINS A TRANSLATION OF TWO ARTICLES FROM THE RUSSIAN PERIODICAL "NEWS OF HIGHER EDUCATIONAL INSTITUTE, RADIO PHYSICS, GORKY, VOL. 10, NO. 9-10, 1967. COMPLETE BIBLIOGRAPHICAL INFORMATION ACCOMPANIES EACH ARTICLE. CONTENTS+ "PROPAGATION OF CM, MM AND SUB MM RADIO WAVES IN THE EARTH'S ATMOSPHERE" AND "A STUDY OF TROPOSPHERIC ABSORPTION OF RADIO WAVES BY RADIO ASTRONOMY METHOD"**
5131828*VOGLER, L.E. AND VAN HORN, J.S.F.*BIBLIOGRAPHY ON PROPAGATION EFFECTS FROM 10 GHZ TO 1000 THZ*NO #*NO #* MAR 1972*COM-75-10809*A BIBLIOGRAPHY ON E & M WAVE PROPAGATION OVER LINE OF SIGHT PATHS THROUGH THE TROPOSPHERE AT FREQUENCIES ABOVE 10 GHZ. THE REFERENCES ARE DIVIDED INTO THREE MAIN CATEGORIES COVERING THE AREA OF PROPAGATION THROUGH NON-TURBULENT CLEAR ATMOSPHERE AND PRECIPITATION.**
513181 *THOMPSON, W.I.*A REVIEW OF RADIOMETER MEASUREMENTS OF ATMOSPHERIC ATTENUATION AT WAVELENGTHS FROM 75 CENTIMETERS TO 2 MILLIMETERS (LITERATURE SEARCH)*NASA-TN D-5087*NO #* APR 1969*N69-22949*PUBLISHED VALUES OF VERTICAL ATTENUATION RESULTING FROM RADIOMETRIC MEASUREMENTS OF ABSORPTION AND EMISSION OF THE EARTH. ATMOSPHERE IN THE WAVELENGTH RANGE FROM 75 CM (.4 GHZ) TO 2 MM (150 GHZ) ARE PRESENTED. THE LITERATURE SEARCH INCLUDED A REVIEW OF SEVERAL HUNDRED PUBLICATIONS. THESE DATA EMPHASIZE THE NEED FOR FURTHER THEORETICAL AND EXPERIMENTAL WORK IN THE CALCULATION AND MEASUREMENT OF ATTENUATION IN THIS PORTION OF THE SPECTRUM.**
733731B*NO #*DESIGN OF A SATELLITE INSTRUMENT FOR MEASUREMENT OF THE MILLIMETER CHARACTERISTICS OF ATMOSPHERIC OZONE* NAS5-12-117*NO #*1969*N69-32183*THE OBJECTIVE WAS TO SELECT AN OZONE RESONANT LINE (APPROX 100 GHZ) WITH SUFFICIENT INTENSITY WHICH COULD BE DETECTED WITH A SIGNAL TO NOISE RATES (FROM A SPACE-BORNE RADIOMETER) ADEQUATE TO ALLOW RESOLUTION OF THE LINE PROFILE TO THE PRECISION REQUIRED FOR THE INVERSION. A FURTHER STIPULATION WAS THAT THE TECHNIQUES AND COMPONENTS INCORPORATED IN THE DESIGN OF THE SATELLITE INSTRUMENT, OR NEAR, CURRENT STATE OF THE ART.**

1231619*GAUT, N.E.*INTERACTION MODEL OF MICROWAVE ENERGY AND ATMOSPHERIC VARIABLES*CONTRACT NAS8-26273*NO #*APR 20, 1971*N71-25079*RESULTS ARE PRESENTED FOR A STUDY OF THE EFFECTS OF WATER VAPOR, LIQUID WATER, AND ICE UPON RADIATIVE TRANSFER PROCESSES AT MICROWAVE FREQUENCIES AND IN THE FAR IR. THE FUNDIMENTAL PROCESSES BY WHICH THESE SPECIES INTERACT WITH MICROWAVE ENERGY ARE DISCUSSED AND THEIR STATISTICS ANALYZED IN TERMS OF THEIR APPLICATION TO A RANGE OF REMOTE SENSING PROBLEMS.**

511174A*IPPOLITO, JR., L.J.*EARTH SATELLITE PROPAGATION ABOVE GHZ: PAPERS FROM THE 1972 SPRING URSI SESSION ON EXPERIMENTS AND UTILIZING THE AFS-5 SATELLITE*NO #*NO #*MAY 1972*N72-30141*THIS DOCUMENT PRESENTS A COLLECTION OF PAPERS FROM THE SPECIAL SESSION ON EARTH-SATELLITE PROPAGATION ABOVE 10 GHZ, PRESENTED AT THE INTERNATIONAL UNION OF RADIO SCIENCE (USNL-VRSI), APRIL 1972, WASHINGTON, D.C. A COMPLETE LIST OF PUBLISHED REPORTS AND PRESENTATIONS RELATED TO THE ATS-5 MM WAVE EXPERIMENT IS INCLUDED AT THE END OF THIS DOCUMENT.**

212371C*HODGE, D.B.*A SIMPLE METHOD FOR THE DETERMINATION OF EFFECTIVE RAIN CELL DIMENSIONS AND ORIENTATION*CONTRACT NGR-36-008-080*NO #*SEPT 1973*N74-10578*A SIMPLE METHOD IS PROPOSED FOR THE DETERMINATION OF EFFECTIVE RAIN CELL DIMENSIONS AND ORIENTATION. TWO RAIN CELL MODELS HAVE BEEN CONSIDERED; THE CIRCULAR CELL AND THE ELLIPTICAL CELL. IN BOTH MODELS IT IS ASSUMED THAT THE RAIN RATES CONSTANT THROUGHOUT THE CELL ---. THE RESULTING RAIN CELL CHARACTERISTICS ARE OF DIRECT VALUE IN THE PREDICTION OF MM WAVELENGTH ATTENUATION STATISTICS ON BOTH SINGLE TERMINAL AND DIVERSITY EARTH SPACE PROPAGATION PATH AS WELL AS POINT TO POINT DOMESTIC LINKS.**

511173A*IPPOLITO, L.J.*TWENTY AND THIRTY GHZ MILLIMETER WAVE EXPERIMENTS WITH THE ATS-6 SATELLITE*NO #*NO #*1975*N75-33154*THE ATS-6 (APPLICATIONS TECHNOLOGY SATELLITE) MM WAVE EXPERIMENT, DEVELOPED AND IMPLEMENTED BY THE NASA GODDARD SPACE FLIGHT CENTER (GSFC), HAS PROVIDED THE FIRST DIRECT MEASUREMENT OF 20 AND 30 GHZ EARTH-SPACE LINKS FROM AN ORBITING SATELLITE. THIS REPORT CONTAINS THE FIRST COMPREHENSIVE PUBLICATION OF INITIAL DATA RESULTS OF THE ATS-7/6 MM WAVE EXPERIMENT FROM THE (7) MAJOR PARTICIPATING ORGANIZATIONS.**

511172B*FANG, D.J.*PRECIPITATION ATTENUATION STUDIES BASED ON MEASUREMENTS OF ATS-6 20-30-GHZ BEACON SIGNALS AT CLARKSBURG, MD*CONTRACT NAS5-20740*NO #*AUG 1976*N77-23295*COMSAT LABS PARTICIPATED IN THE MM WAVE PROD. EXPERIMENT UNDER NASA NAS5-20740, PERFORMING MEASUREMENTS OF THER 20/30-GHZ ATS-6 SATELLITE BEACON SIGNALS AND AUXILLIARY MEASUREMENTS SUCH AS RADIOMETRIC SKY TEMPERATURES AND MINUTE PRECIPITATION AT CLARKSBURG, MD. THESE MEASUREMENTS WERE INTENDED TO ADVANCE UNDERSTANDING OF THE PROPAGATION CHARACTERISTICS OF THE EARTH SATELLITE PATH AT FREQUENCIES OVER 10 GHZ.**

A52461C*NOOREN, G.J.L.*THEORY OF AEROSOL DETERMINATION BY MEANS OF LIDAR (IN DUTCH)*NO #*NO #*SEPT 1976*N77-24933*THIS REPORT DESCRIBES A STUDY OF THE FEASIBILITY OF AEROSOL

DETERMINATION BY MEANS OF A 2-COLOR MIE-LIDAR. THESE AEROSOLS ARE IMPORTANT FOR DETERMINATION OF FAR IR TRANSMISSION. AFTER AN OUTLINE OF THE SCATTERING THEORY AND A DESCRIPTION OF AEROSOL PROPERTIES, THE RESULTS ARE GIVEN OF CALCULATIONS FOR SOME AEROSOL MODELS. THE EXTINCTION OF FOGS DOESN'T SEEM TO BE STRONGLY WAVELENGTH-DEPENDENT. EXPERIMENTAL ERRORS TAKEN INTO ACCOUNT ONLY IN SOME CASES DETERMINATION OF AEROSOL PARTICLE SIZE SEEMS POSSIBLE, BUT WILL NOT CHANGE THE CONCLUSION DRASTICALLY.**

523732H*MOUNT, W.D.*CAPABILITIES OF MILLIMETER WAVE RADIOMETERS FOR REMOTELY MEASURING TEMPERATURE PROFILES PERTINENT TO AIR POLLUTION*CONTRACT PH86-67-76*NO #*1968* PB-186 189*ANALYTICAL AND EXPERIMENTAL RESULTS ARE PRESENTED FOR REMOTELY MEASURING LOW-LEVEL AIR TEMPERATURE PROFILES WITH A MM WAVE RADIOMETER. NEARLY A 1 TO 1 CORRESPONDENCE EXISTS BETWEEN THE RADIOMETERS AND THE RADIOSONDE AND/OR TOWER DATA OUTPUT FOR SUPER DIELECTRIC AND OTHER LAPSE TEMPERATURE CONDITIONS. A MEASURE OF THE HEIGHT AND THE MAGNITUDE OF TEMPERATURE INVERSIONS WAS ALSO OBTAINED REMOTELY WITH THE RADIOMETRIC TECHNIQUES. THE RADIOMETRIC MAGNITUDE OF THE INVERSION IS CONSTANTLY LESS THAN THAT MEASURED DIRECTLY AND YET NO ATTEMPT HAS BEEN MADE TO CORRECT FOR THIS BIAS. THE FEASIBILITY HAS BEEN ESTABLISHED FOR MEASURING REMOTELY THE UNSTABLE, NEUTRAL, AND STABLE METEOROLOGICAL CONDITIONS PERTINENT TO AIR POLLUTION PROBLEMS.**

513381K*HUGHES, V.W. AND LAMB, JR., W.E.*MICROWAVE AND O/ OPTICAL SPECTROSCOPY OF ATOMS, MOLECULES AND PLASMAS AND ATOMIC COLLISION STUDIES.....*CONTRACT # F44620-71-C-0042*NO #*SEPT 1974*AD-A000 577*RESEARCH HAS BEEN DONE ON THE FOLLOWING TOPICS: 1) "QUANTUM ELECTRODYNAMICS AND FUNDAMENTAL ATOMIC CONSTANTS," INCLUDING "PRECISION STRUCTURE USING FAST MONOENERGETIC ATOMIC BEAMS," 2) "ATOMIC AND MOLECULAR STRUCTURE, INCLUDING VIBRATIONAL STATES OF HD+"; 3) "ELECTRON- AND HEAVY PARTICLE-ATOMIC COLLISIONS," INCLUDING "ELECTRON TRANSFER STUDIES USING AN ATOMIC HYDROGEN TARGET, INCLUDING COLLISIONS OF ALPHA PARTICLE WITH HYDROGEN AND HELIUM ATOMS," STUDIES USING THE MERGING BEAMS TECHNIQUE: ONE AND TWO ELECTRON MOLECULAR COLLISIONS IN THE EV ENERGY RANGES", "POLARIZED ELECTRONS,""LOW ENERGY SCATTERING OF POLARIZED ELECTRONS BY POLARIZED HYDROGEN ATOMS," AND "TIME OF FLIGHT INVESTIGATION OF MOLECULAR DISSOCIATION PRODUCTS AND THE COLLISIONAL QUENCHING OF METASTIBLE ATOMS," 4) "THEORY OF OPTICAL MASERS."**X

513761I*SHEFRIN, K.S., EDITOR*TRANSFER OF MICROWAVE RADIATION IN THE ATMOSPHERE, TRANSACTIONS OF THE MAIN GEOPHYSICAL OBSERVATORY IN. A.I. VOYEGLEAR NO. 222*NO #* HYDROMETEOROLOGICAL PRESS, LENINGRAD1968*JULY 1964*NASA TTF-590*THIS COLLECTION OF ARTICLES CONTAINS THE RESULTS OF BOTH THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THERMAL EMISSION FROM THE ATMOSPHERE AND THE UNDERLYING SURFACE IN THE CM AND MM REGIONS OF THE SPECTRUM. THE PROBLEM OF UWAVE RADIATION IN A CLOUD-FREE ATMOSPHERE, IN CLOUDS, AND IN PRECIPITATION ARE STUDIED; THE REFLECTION

AND RADIATION OF THE ROUGH SURFACE OF THE SEA AND THE ICE COVER ARE INVESTIGATED AND THE CONTRAST IN RADIO BRIGHTNESS TEMPERATURE OF THE ICE FIELD, THE ZONE OF CLOUD COVER, PRECIPITATION AND THE REGIONS OF REVERSED HUMIDITY ARE EVALUATED. THE POSSIBILITY OF USING RADIO EMISSION IS EVALUATED FROM THE VIEWPOINT OF SOLVING INVERSE PROBLEMS, I.E., SOUNDING OF THE ATMOSPHERE AND THE UNDERLYING SURFACE FROM AIRCRAFT.**

523531A*KONDRATYEV, K.Y., ET AL.*MICROWAVE REMOTE ENVIRONMENT SOUNDING*NASA TT-F-16930*NO #*JULY 1976*N76-27449*THIS IS A LONG ARTICLE ON MICROWAVE REMOTE SOUNDING -- MICROWAVE RADIOMETRY. CALCULATIONS ARE FOR THE .8CM - 3.2 CM WAVELENGTH REGIONS, ALTHOUGH THERE ARE DISCUSSIONS ABOUT MEASUREMENTS IN THE .3-3.2 CM RANGE IN THE ATMOSPHERE, SOIL, OIL SPILLS, ICE COVER. CALCULATIONS OF DIELECTRIC CONSTANTS OF SOILS ARE ALLUDED TO, IN THE 8.1 - 214 MM RANGE. THERE IS A 167-ELEMENT BIBLIOGRAPHY IN DIELECTRICS, RADIOMETRY THAT IS VERY GOOD.**

212761G*KOMEN, M.*METHODS FOR CORRECTING MICROWAVE SCATTERING AND EMISSION MEASUREMENTS FOR ATMOSPHERIC EFFECTS*NASA-CR-14718*NO #*AUG 1975*N76-27629*ALGORYTHMS HAVE BEEN DEVELOPED TO PERMIT CORRECTION OF SCATTERING COEFFICIENT AND BRIGHTNESS TEMPERATURE FOR SKYLAB-5-193 RAD SCAT (13.9 GHZ RADIOMETER) FOR THE EFFECTS OF CLOUD ATTENUATION. THESE ALGORYTHMS DEPEND ON A MEASUREMENT OF THE VERTICALLY POLARIZED EXCESS BRIGHTNESS TEMPERATURE AT 50-DAY INCIDENCE ANGLE. THE EXCESS TEMPERATURE IS CONVERTED FROM EQUIVALENT 50 DAY ATTEN., WHICH MAY THEN BE USED TO ESTIMATE THE HORIZONTALLY POLARIZED EXCESS BRIGHTNESS TEMPERATURE AND REDUCED SCATTERING COEFFICIENT AT 50 DEG. FOR ANGLES OTHER THAN 50 DEG, THE CORRECTION ALSO REQUIRES USE OF THE VARIATION OF EMISSIVITY WITH SALINITY AND WATER TEMPERATURE. ROUTINES IN FORTRAN IV ARE PRESENTED FOR THESE CALCULATIONS.**

231581K*BLUE, M.D.*PERMITTIVITY OF WATER AT MILLIMETER WAVE LENGHTS*N56-5082*NO #*AUG 1976*N76-30911*THIS REPORT COVERS WORK PERFORMED ON THE PERMITTIVITY OF SEAWATER AND ICE AT 100 GHZ. MEASUREMENTS ON WATER WERE FROM 0 DEG C TO 50 DEG C; ON ICE, NEAR -10 DEG C. IN ADDITION, A SMALL NUMBER OF MEASUREMENTS WERE MADE ON REFLECTIVITY OF ABSORBER MATERIALS USED IN THE PROGRAM "RESEARCH ON MM WAVE TECHNIQUES." AT 103.86 GHZ, THE FOLLOWING RESULTS ARE GIVEN: FREE WATER: REFLECTIVITY - 0.392 + OR - .014; INDEX OF REFRACTION M = 3.24 - I 1.825: APPROPRIATE DIELECTRIC CONSTANTS ARE: E' - IE" = 7.16 - I 11.825. FOR SEA WATER (.7N SOLAR OF NACL). R(SALT WATER)/R(FRESH WATER) = 1.0056 + OR - .010. FOR SALT WATER FROM THE GULF OF MEXICO, R(SALT WATER)(R(FRESH WATER)) = 1.004I.008. THUS, ONE CAN'T DETECT THE EFFECT OF SALT IN WATER AT 100 GHZ. FOR ICE AT 99 GHZ; R(ICE) = .0785 + OR - .0112; N = 1.78 + OR - .08; E = 3.17 + OR - .27. THE LITERATURE INDICATES NO ABSORPTION OR DISPERSION OF ICE IN MM-CM BANDS.**

212371M*MAWIRA, A. AND DICK, J.*DEPOLARIZATION BY RAIN. SOME RELATED THERMAL EMISSION CONSIDERATIONS*NO #*

EINDHOVEN UNIVERSITY, REPORT TH-75-E-61*SEPT 1975*
N77-21284*THIS REPORT DEALS WITH THE E & M PROPERTIES OF
A MEDIUM CONTAINING A AXISYMMETRIC RAIN DROPS. IN SECTION
2 ARE OUTLINED THE BASIC ASSUMPTIONS UNDERLYING THE IN-
VESTIGATION. SECTION 3 CONCERNS THE PROPAGATION OF A
MONOCHROMATIC PLANE WAVE THROUGH THIS MEDIUM. SECTION 4
DEALS WITH THE ASPECT OF THERMAL EMISSION CLOSELY CONNECTED
WITH THE PROBLEM. THE STOKES SPECTRAL VECTOR REPRESENTATION
OF THE THERMAL EMISSION FIELD IS PRESENTED. THE DIFFERENTIAL
EQUATIONS DERIVED IN SECTION 3, AS WELL AS SOME THERMO-
DRYNAMIC CONSIDERATIONS ARE USED TO DERIVE A TRANSFER
EQUATION FOR THE STOKES SPECTRAL VECTOR. THE SOLUTION OF
THIS EQUATION THEN YIELDS EXPRESSIONS FOR THE GENERALIZED
ANISOTROPIC EFFECTIVE TEMPERATURE VECTOR. FINALLY, IN
SECTION 5, THE RELATIONS BETWEEN VARIOUS QUANTITIES
REFERRING TO MONOCHROMATIC SIGNALS SUCH AS THE CROSS
POLARIZATION PARAMETERS AND THE THERMAL EMISSION MAGNITUDE
ARE DISCUSSED. DATA IS PRESENTED FOR 11, 18.1 AND 30 GHZ
RADIATION, PROPAGATION THROUGH RAIN. 34 REFS.**
523171E*MAZUR, D.G.; MACKEY, R.J.; AND TANNER, S.G.*FORTY
AND 80 GHZ TECHNOLOGY ASSESSMENT AND FORECAST INCLUDING
EXECUTIVE SUMMARY*NO #*NO #*MAY 1976*N76-27319*THE RESULTS
OF A SURVEY TO DETERMINE CURRENT DEMAND AND TO FORECAST
GROWTH IN DEMAND FOR USE OF THE 40 AND 80 BANDS DURING
THE 1980-2000 TIME PERIOD ARE GIVEN. THE CURRENT STATE
OF THE ART IS PRESENTED AS WELL AS THE TECHNOLOGY REQUIRE-
MENTS OF CURRENT AND PROJECTED SERVICES. POTENTIAL DEVELOP-
MENTS WERE IDENTIFIED AND A FORECAST IS MADE. THE IMPACTS
OF ATMOSPHERIC ATTENUATION IN THE 40 AND 80 GHZ BANDS WERE
ESTIMATED FOR BOTH WITH AND WITHOUT DIVERSITY. THREE
SERVICES FOR THE 1980-2000 TIME PERIOD -- INTERACTIVE TV,
HIGH QUALITY 3 STEREO PAIR AUDIO, AND 30 MB DATA -- ARE
GIVEN WITH SYSTEM REQUIREMENTS AND DOWN-LINK CALCULATIONS.**
B61282N*QUERRY, MARVIN R.; OSBORNE, GORDON; LICS, KEN;
JORDAN, RAY AND COVENEY, JR., R.M.*COMPLEX INDEX OF RE-
FRACTION OF LIMESTONE IN THE VISIBLE AND IR*NO #*APPLIED
OPTICS, VOL. 17, NO. 3, 353-356,*1978*NO #*
NEAR NORMAL-INCIDENCE RELATIVE SPECTULAR REFLECTANCE WAS
MEASURED THROUGHOUT THE 0.2-32.8-UM WAVELENGTH REGION FOR
THREE CUT AND POLISHED SAMPLES OF BETHANY FALLS LIMESTONE.
WATER, FOR WHICH THE COMPLEX REFRACTIVE INDEX IS WELL
KNOWN, WAS THE REFLECTANCE STANDARD. ALTHOUGH THE VISUAL
APPEARANCES OF THE THREE SAMPLES WERE QUITE DIFFERENT,
THE RELATIVE REFLECTANCE SPECTRA FOR THE THREE SAMPLES
WERE NEARLY IDENTICAL. THE THREE RELATIVE REFLECTANCE
SPECTRA WERE AVERAGED TO OBTAIN A COMPOSITE RELATIVE
REFLECTANCE SPECTRUM. KRAMERS-KRONIG ANALYSIS OF THE
COMPOSITE RELATIVE REFLECTANCE SPECTRUM THEN PROVIDED
SPECTRAL VALUES OF THE COMPLEX REFRACTIVED INDEX FOR LIME-
STONE. A CLASSICAL LORENTS DISPERSION ANALYSIS WAS ALSO
MADE OF THE COMPOSITE RELATIVE REFLECTANCE SPECTRUM, AND
THE RESULTING DISPERSION PARAMETERS WERE TABULATED. INFRA-
RED BANDS CHARACTERISTIC OF THE CARBONATE ION CO3 OF THE CALCITE
COMPRISING THE LIMESTONE APPEARING AS STRONG FEATURES IN THE
SPECTRA.**

B612618*RAO, N.C.*EVALUATION OF INDEX PROPERTIES OF NATURAL FORMATION BY POLARIMETER STUDIES*NO #*NO #*SEPT 1974*AD-A000 901*THE DEPENDENCE OF THE POLARIZATION OF RADIATION REFLECTED BY SURFACES COMPOSED OF NATURALLY OCCURRING SOIL ON INDEX PROPERTIES, SUCH AS MOISTURE (WATER) CONTENT, TEXTURE, AND COMPOSITION OF THE SOIL SAMPLES HAS BEEN EXAMINED IN DETAIL IN THE LABORATORY IN SELECTED SPECTRAL INTERVALS OVER THE VISIBLE AND NEAR IR REGIONS.**

B611639*HINDS, B.D.; KIMBERLIN, R.F.; AND HOLDALE, G.B.*BOUNDARY LAYER DUST OCCURRENCE, I: ATMOSPHERIC DUST OVER THE WHITE SANDS MISSILE RANGE*ECOM-DR-75-2*NO #*APRIL 1975*AD-A010 335*TH REPORT PROVIDES AN OVERVIEW OF PUBLISHED AND SOME UNPUBLISHED DATA ON ATMOSPHERIC DUST OVER THE WHITE SANDS MISSILE RANGE, NM AREA. THE SURVEY ENCOMPASSES THE OCCURRENCE OF DUSTY CONDITIONS, AND THE EFFECT OF THE DUST ON THE PROPAGATION OF E & M AND ACOUSTIC ENERGY AND PER-SE PROPERTIES OF DUST.**

B61161A*HINDS, B.D. AND HOLDALE, G.B.*BOUNDARY LAYER DUST OCCURRENCE. IV. ATMOSPHERIC DUST OVER SELEC.....*ECOM-DR-77-3*NO #*JUNE 1977*AD-A041 077*THIS IS THE FOURTH IN A SERIES OF REPORTS DESIGNED TO PROVIDE A GUIDE FOR THE OCCURRENCE OF DUST OVER SELECTED GEOGRAPHICAL AREAS. TABULAR DATA ON THE DURATION AND THE DIURNAL AND MONTHLY OCCURRENCE OF BLOWING DUST (VISIBILITY LESS THAN 11 KM) AND OF DUST STORMS (VISIBILITY LESS THAN 1 KM) ARE PRESENTED BY 45 STATIONS WHICH AVERAGED AT LEAST 3.7 DAYS (1%) WITH BLOWING DUST.**

B61162C*HINDS, B.D. AND HOLDALE, G.B.*BOUNDARY LAYER DUST OCCURRENCE, III. ATMOSPHERIC DUST OVER RUSSIA....*ECOM-DR-77-2*NO #*MAY 1977*AD-A040 581*THIS IS 3RD IN A SERIES OF REPORTS DESIGNED TO PROVIDE A GUIDE TO THE OCCURRENCE OF ATMOSPHERIC DUST OVER SELECTED GEOGRAPHIC AREAS. TABULARIZED DATA ON THE DIURNAL VARIATION OF OCCURRENCE BY MONTH AND ON THE DURATION FACTOR FOR SELECTED TIME PERIODS THROUGHOUT THE YEAR FOR BLOWING DUST (VISIBILITY LESS THAN 11 KM) AND OF DUST STOEM (VISI-BILITY LESS THAN 1 KM) ARE PRESENTED FOR 85 STATIONS IN SIBERIA, 75 SATATIONS IN SOVIET CENTRAL UNION, AND 54 STATES IN THE USSR.**

D21661F*SEXTON, M.C.*SUBMILLIMETER LASER, MICROWAVE AND SPECTROSCOPIC DIAGNOSTICS OF IONIZATION IN GASEOUS PLASMAS*GRANT AFOSR-72-2338*NO #*JULY 1975*AD-A028 403*THE DEPENDENCE OF THE REACTION RATE CONSTANT K FOR THE PROCESS AR(+) + 2AR GOES TO AR(+) 2 + AR WAS EXAMINED WITH 35 GHZ RADIATION OVER 1.E13 - 1.E11 ELECTRONS CM-3 IN ARGON AFTERGLOWS. K WAS VARIED FROM 2.9 TO 1.5X10-31 CM3 SEC-1 AS THE INPUT POWER VARIED FROM 15 TO 350 MG CM-3. A NUMERICAL ANALYSIS OF THE HELIUM AFTERGLOW DECAY WAS CARRIED OUT WITH A 1-DIMENSIONAL CYLINDRICAL CODE PROGRAMMED SUCH THAT IMPORTANT PARAMETERS CAN BE READILY VARIED TO SUCH EXPERIMENT. THE PLASMA CHARACTERISTICS OF A PULSED HCN LASER WERE STUDIED WITH LINE EMISSION SHOWING SIGNIFICANT PRODE COMPRESSION NEAR THE CONTROL DENSITY.**

222411D*DOWNS, A.R.*A MODEL FOR PREDICTING THE RAIN BACK-

SCATTER FROM A 70-GHZ RADAR*BRL-MR-2467*NO #*MAR 1975*AD-A009 699*A MATHEMATICAL MODEL REQUIRING LITTLE COMPUTER TIME HAS BEEN DEVELOPED TO PREDICT THE INTENSITY OF 70-GHZ RADAR BACKSCATTER BY RAIN. THE BACKSCATTER MODEL IS BASED ON AN OPTICAL RADIATIVE TRANSFER MODEL DEVELOPED UNDER THE AMC TARGET SIGNATURE ANALYSES PROGRAM. THE DESCRIBED APPROACH WAS TAKEN IN ORDER TO DEVELOP A BACKSCATTER EQUATION INDEPENDENT OF THE RADAR FREQUENCY SO THAT THE EQUATION CAN BE SOLVED BY SPECIFYING THE NEEDED FREQUENCY DEPENDENT INPUTS. THE BACKSCATTER EQUATION IS DERIVED AND THE INPUTS PERTAINING TO 70 GHZ ARE CALCULATED AND PRESENTED IN THE FORM OF GRAPHS AND TABLES.**

C11731B*SILVER, SAMUEL AND WELCH, WILLIAM J.*SOLAR RADIATION AND ATMOSPHERIC ABSORPTION IN THE MILLIMETER*NO #*NO #*JAN 1970*AD-703 697*THIS IS A PROGRESS REPORT FOR THE PERIOD AUG 1, 1969 - JAN 31, 1970 ON MM WAVE-ASTRONOMY ACTIVITY AT THE SPACE SCIENCES LAB., U. OF CAL., BERKELEY. OBSERVATIONAL STUDIES EITHER IN PROGRESS OR COMPLETE ARE FOR THE FOLLOWING RADAR SOURCES: VIRGO A, SATURN, VERNUS, JUPITER, THE SUN, GALACTIC MOLECULAR LENS SOURCES, AND THE OBSERVABLE QUASI STELLAR OBJECTS. FUTURE DEVELOPMENTS WERE DISCUSSED - AN INTERFEROMETER SYSTEM - EARTH 1-20 FT ANTENNA AND A 10-FT ANTENNA.**

B21551E*MCSWEENEY, ALBERT AND SHEPPARD, ALBERT P.*MILLIMETER AND SUBMILLIMETER WAVE DIELECTRIC MEASUREMENTS WITH AN INTERFERENCE SPECTROMETER*CONTRACT NONR-991(13)*NO #*APR 1970*AD-709 983*THIS IS A PROGRESS REPORT SUMMARIZING WORK DONE UNDER THE ABOVE CONTRACT FROM 15 APRIL 1964 - 14 APRIL 1970. A NUMBER OF ARTICLES ARE GIVEN IN ENTIRETY, REPORTED FROM THE OPEN LITERATURE. THE CHIEF EXPERIMENTAL TOOL CONSTRUCTED WAS A 30-CM APERTURE MICHELSON INTERFERENCE SPECTROMETER FOR STUDYING DIELECTRIC MATERIALS AT FRQUENCIES FOR 50-3000 GHZ REGION (1.67-100 CM-1). THIS REPORT SUMMARIZES HOW THIS INSTRUMENT HAS BEEN USED TO OBTAINDIELECTRIC CONSTANT, LOSS TANGENT AND TRANSMISSION COEFFICIENT OF MATERIAL. RESULTS OF MEASUREMENTS ARE GIVEN AS APPENDICES TO THIS REPORT, ON DIELECTRIC MEASUREMENTS.**

522682D*ISHIMARU, A. AND HONG, S.T.*PROPAGATION CHARACTERISTICS OF A PULSE WAVE IN A DISCRETE TIME*CONTRACT NO. F19628-74-C-0009*NO #*MAR 1974*AD-782 029*THE PROPAGATION CHARACTERISTICS, COHERENCE TIME, COHERENCE BANDWIDTH, AND PULSE TRANSFORM OF A WAVE PASSING THROUGH A DISCRETE TIME VARYING RANDOM MEDIUM ARE CONSIDERED IN THIS REPORT. THEY ARE FORMULATED ON FOLDY-KOERSBY THEORY. USING THE FIRST ORDER SOLUTION, EXPLICIT EXPRESSIONS ARE GIVEN FOR PLANE, SPHERICAL, AND BEAM WAVES. THESE EXPRESSIONS APPLY TO THE CASES OF SMALL TRANSMITTING BANDWIDTH AND FOR SHORT PROPAGATION DISTANCES. NUMERICAL CALCULATIONS ARE MADE FOR MM WAVE PLANE AND SPHERICAL WAVES PROPAGATED THROUGH RAIN.**

522681C*SCREENIVASHIAK, T. AND ISHIMARU, A.*PLANE WAVE PULSE PROPAGATION THROUGH ATMOSPHERIC TURBULENCE AT MM AND OPTICAL FREQUENCIES*CONTRACT F19628-74-C-0005*NO #*MAR 1974*AD-782 030*STARTING FROMTHE PARABOLIC EQUATION FOR A WAVE PROPAGATING IN A RANDOM MEDIA, THE EQUATION

FOR THE GENERAL MUTUAL COHERENCE FUNCTION IS DERIVED, AND A SOLUTION IS OBTAINED FOR THE SAME USING A PERTURBATION TECHNIQUE, ASSUMING THE KOLMOGWOR SPECTRUM FOR THE FLUCTUATIONS OF THE REFRACTIVE INDEX AS IT IS SHOWN THAT THE SOLUTION SO OBTAINED IS EXACT WHEN THE COHERENCE FUNCTION IS EVALUATED AT A SINGLE POINT, AND AT THE SAME TIME, BUT AT TWO DIFFERENT FREQUENCIES.**

523731H*ALTSHULER, E.E.; WULFSHERG, K.N.; AND KALAGHAN, PAUL M.*ATMOSPHERIC EMISSION STATISTICS AT 35 GHZ*NO #*JOURNAL DE RESHORCHES ATMOSPHERIQUES, P 438-442*1974*AD-782-741*RADIOMETRIC METHODS OF OBTAINING TOTAL ATMOSPHERIC ATTENUATION ARE REVIEWED. ATMOSPHERIC EMISSIONS AT 35 GHZ WERE CONTINUOUSLY MONITORED BY A ZENITH POINTING RADIOMETER DURING THE PERIOD FROM NOV 1972 THROUGH JULY 1973. SEASONAL PERCENT TIME DISTRIBUTIONS OF APPARENT ZENITH SKY TEMPERATURE AND THE CORRESPONDING ATTENUATION ARE PRESENTED. SEPARATE PERCENT TIME DISTRIBUTIONS FOR APPARENT SKY TEMPERATURE AND RAIN RATE WERE ALSO OBTAINED FROM THOSE DATA AND IT WAS POSSIBLE TO PLOT ATTENUATION VS RAIN RATE BY USING CORRESPONDING VALUES OF THOSE PARAMETERS HAVING THE SAME PERCENT TIME. DURINGTHE MEASUREMENT PROGRAM THERE WERE 28 RAIN STORMS; IT WAS FOUND THAT APPARENT SKY TEMPERATURE AND RAIN RATE WERE POORLY CORRELATED.**

622731F*BARRETT, A.H.; LAM, K.S.; AND STAELIN, D.H.*ATMOSPHERIC MEASUREMENTS AT MILLIMETER WAVELENGTHS*CONTRACT F19628-73-C-0196*NO #*DEC 1974*AD-A006 128*THIS STUDY ADDRESSES THE PROBLEM OF MEASURING METEOROLOGICAL PARAMETERS BY VIRTUE OF THE NATURAL THERMAL EMISSION OF THE ATMOSPHERE OF MM WAVELENGTHS. THREE TOPICS ARE DISCUSSED: 1) THE O2 ABSORPTION COEFFICIENTS ARE COMPUTED USING A FOREIGN GAS APPROACH BASED ON THE LIOUVILLE SPACE FORMULATION. NUMERICAL RESULTS WERE OBTAINED FOR PURE O2 WITH ROTATIONAL QUANTUM NUMBER N=1 THROUGH N=11 FOR T = 300 DEG K. 2) THE JOINT USE OF THE 60 GHZ AND 118 GHZ O2 RESONANCES FOR DETERMINING CLOUD WATER CONTENT AND ALTITUDE DISTRIBUTION IS DISCUSSED. 3) THE 118 GHZ RECEIVER FOR MEASURING THE 118 GHZ ATMOSPHERIC SPECTRUM IS DESCRIBED.**

223181E*ALTSHULER, E.E. AND EBEOGLU, D.B.*DOD WORKSHOP ON MILLIMETER WAVE TERMINAL GUIDANCE SYSTEMS*NO #*NO #*MAY 1976*AD-A026 270*THIS IS A PROCEEDINGS OF A ONE-DAY WORKSHOP HELD AT A.F. CAMBRIDGE RESEARCH LABORATORIES (AFCRL) ON 28 JAN 1976 ON MM WAVE MEASUREMENTS IN ADVERSE WEATHER. THE OBJECTIVE WAS TO EXTEND THE LEVEL OF UNDERSTANDING OF THE ADVERSE WEATHER PROBLEM WITHIN THE DOD IS THAT MM SYSTEMS CAN BE TESTED AND DESIGNED EFFECTIVELY. THE KEY FREQUENCIES WERE 35 AND 95 GHZ. IT WAS CONCLUDED THAT A BROAD PROGRAM OF CONTROLLED EXPERIMENTS TO MEASURE THE EFFECTS THAT PRECIPITATION AND COOL BACKGROUND WOULD HAVE ON A SYSTEM PERFORMANCE SHOULD BE CONDUCTED. IN ADDITION, IT WAS RECOMMENDED THAT FLIGHT TESTS OF MM WAVE SYSTEMS UNDER ACTUAL ADVERSE WEATHER CONDITIONS BE CARRIED OUT.**

B21281D*YAMAMOTO, HIROSHI AND OHKAWA, SUMIS*MEASUREMENT OF THE DIELECTRIC CONSTANT AND LOSS TANGENT BY THE TRANS-

MITTED-REFLECTED WAVE METHOD IN THE MM WAVE RANGE*NO #*
IEEE TRANS. MICROWAVE THEORY ' TECH. MTT-19, 827-829*
OCT 1971*NO #*A NEW TECHNIQUE FOR MEASURING THE DIELECTRIC
CONSTANT AND LOSS TANGENT OF MATERIALS IN THE MILLIMETER
WAVE RANGE IS DESCRIBED. THE MEASUREMENT APPARATUS AND
THE ANALYSIS IS CONSIDERABLY SIMPLER THAN THAT USING
CONVENTIONAL TECHNIQUES. THE NEW TECHNIQUE IS BASED UPON
A SIMPLE GEOMETRICAL OPTICS APPROXIMATION IN WHICH A
PLANE REFLECTOR IS ROTATED SO AS TO MAXIMIZE THE TRANS-
MITTED-REFLECTED WAVE POWER THROUGH THE MATERIAL. ONLY
ONE MICROWAVE FORM IS USED IN THE MEASUREMENT.**

5411331*BUSSOLETTI, E. AND BULUTEUU, J.P.*DETERMINATION OF
H2O/O2 STRATOSPHERIC MIXING RATIO FROM HIGH RESOLUTION
SPECTRA IN THE FAR IR*NO #*INFRARED PHYSICS, VOL. 14,
293-302*1974*NO #*STRATOSPHERIC EMISSION SPECTRA WERE
OBSERVED ABOARD A CARAVELLE IN THE FREQUENCY RANGE 30-250
CM-1. OXYGEN LINES UP TO 200 CM-1 HAVE BEEN IDENTIFIED
IN THESE SPECTRA AND COMPARED WITH LINES THEN ACTUALLY
PREDICTED AND LINES DETECTED PREVIOUSLY BY OTHER AUTHORS
UP TO 115.7 CM-1. USING A METHOD SUGGESTED BY BURROUGHS
AND HARRIS WE HAVE MEASURED THE MIXING RATIO U OF WATER
VAPOR TO AIR FROM OUR SPECTRA. THE VALUES THAT WE FIND
ARE IN GOOD AGREEMENT WITH THOSE FOUND BY DIFFERENT AUTHORS
IN PAS YEARS AT AIRCRAFT AND BALLOON ALTITUDES. IN
ADDITION TO THIS, AN UNEXPECTED BEHAVIOR IS SEEN WHEN
PAIRS OF LINES OF HIGH FREQUENCY ARE USED. THE VALUES
OF U CHANGE IN TIME CORRESPONDING TO THE PASSAGES OF THE
AIRCRAFT THROUGH STRATOSPHERIC REGIONS WHERE DIFFERENT
PHYSICAL CONDITIONS EXIST.**

5411329*DALL'OGLIO, G.; FONTE, S.; ET AL.*ATMOSPHERIC WINDOWS
AND BROAD BAND PHOTOMETRY IN FAR IR ASTRONOMY*NO #*
INFRARED PHYSICS 14, 335-341*1974*NO #*THE FAR IR ATMO-
SPHERIC WINDOWS HAVE BEEN OBSERVED DURING MANY MONTHS OF
OBSERVATIONS AT THE ALPINE STATION OF TESTA GRIGA (3500 M
ASLI). THE SEASONAL AND DIURNAL VARIATION OF THE ATMO-
SPHERIC TRANSMITTANCE FOR EACH WINDOW HAVE BEEN MEASURED.
THE CONTRIBUTION OF THE MINOR ATMOSPHERE COMPONENTS IS
ALSO DISCUSSED.**

C42131G*DALL'OGLIO, G.; FONTI, S.; GIRALDI, G.; ET AL.*
AN AUTOMATIC RADIOMETER FOR THE MEASUREMENT OF THE ATMO-
SPHERIC EMISSION AND TRANSMITTANCE IN THE FAR IR*
NO #*INFRARED PHYSICS, VOL 14, 303-321*1974*NO #*WE HAVE
DESCRIBED AN INSTRUMENT TO MEASURE THE ATMOSPHERIC TRANS-
MISSION THROUGH THE WINDOWS BETWEEN 300 UM AND 3000 UM.
THE RADIOMETER OPERATES AUTOMATICALLY, SCANNING THE SKY
IN STEPS OF 0.7 DEG FROM THE HORIZON TO THE ZENITH, WITH
THE TIME CONSTANT AS SELECTED BY THE OPERATOR. THE
SPECTRAL DISTRIBUTION OF THE RADIATION IS MEASURED USING A
MICHELSON INTERFEROMETER WITH AN OPTICAL PATH DIFFERENCE
OF + OR - 10 CM. USING A 77 DEG K REFERENCE BLACKBODY,
THE ATMOSPHERIC TRANSMITTANCE CAN BE MEASURED WITHIN AN
ACCURACY OF BETTER THAN 1%. SOME PRELIMINARY RESULTS
ARE DESCRIBED, OBTAINED AT THE ALPINE STATION OF TESTA
GRIGA (3500 M ABOVE SEA LEVEL).**

B522916*TAKAHASHI, SHIN-ICHI*BLACKENING FOR SUB MM WAVE-

LENGTHS*NO #*IR PHYSICS, VOL. 13, 301-303*1973*
NO #*A BLACKENING TECHNIQUE IS DESCRIBED FOR THE FAR IR REGION. IRON SAND POWDER IS FOUND TO BE IN EXCELLENT BLACK MATERIAL FOR THE LONG WAVELENGTH REGION (AND ALSO FLINT GLASS).**

B51583A*BOLDECCHI, M.G. AND MELCHIORRI, B.*MATERIALS FOR MAKING FAR I.R. H: PASS TRANSMISSION FILTERS*NO #* INFRARED PHYSICS, VOL. 13, 184-211, 1973*NO #*A STUDY HAS BEEN MADE OF THE OPTICAL PROPERTIES OF 30 COMPOUNDS SUITABLE FOR MAKING FAR IR FILTERS OF THE YOSHINAGA TYPE. THE TRANSMISSION CURVE OF EACH COMPONENT IN THE FAR I.R. IS GIVEN FOR VARIOUS THICKNESSES OF THE SAMPLE. THE TRANSMITTANCES IN THE NEAR IR IS ALSO GIVEN TO ALLOW AN APPROPRIATE CHOICE OF THE MATERIALS CAPABLE OF CUTTING OFF THE NEAR I.R. RADIATION.**

5521817*REBOWS, B. AND RABACHE, P.*SYNTHETIC TRANSMISSION SPECTRA IN THE FAR-INFRARED FOR THE LOW STRATOSPHERE* NO #*INFRARED PHYSICS, VOL. 15, 189-199*1975*NO #*THE AUTHORS PRESENT A METHOD FOR THEORETICAL ANALYSIS OF SPECTRAL TRANSMISSION APPLIED TO THE LOWER STRATOSPHERE IN THE FAR INFRARED. THE RESULTS ARE PRESENTED AS SYNTHETIC SPECTRA OF HIGH RESOLUTION.**

541731D*HARRIES, J.E.; SWANN, NEW.; CARRUTHERS, G.P. AND ROBINSON, G.A.*MEASUREMENTS OF THE SUB MM STRATOSPHRIC EMISSION SPECTRUM FROM A BALLOON PLATFORM*NO #*INFRARED PHYSICS, VOL. 13, 149-155*1973*NO *A DESCRIPTION IS GIVEN OF THE MEASUREMENT, FROM A BALLOON PLATFORM, OF THE SUB MM WAVELENGTH EMISSION OF THE STRATOSPHERE ABOVE 30 KM. USING A MICHELSON INTERFEROMETER AND FOURIER SPECTROSCOPIC TECHNIQUES, THE SPECTRUM HAS BEEN OBTAINED WITH A RESOLUTION OF .5 CM-1, AND FROM THIS A VALUE OF 1.7 + OR - .8 IN GAMMA/KG FOR THE HUMIDITY MIXING RATIO IN THE MIDDLE STRATOSPHERE HAS BEEN CALCULATED. THE USE OF THIS TECHNIQUE AS A METEOROLOGICAL SOUNDING SYSTEM IS DISCUSSED.**

212171H*ROGERS, R.R.*STATISTICAL RAINSTORM MODELS: THEIR THEORETICAL AND PHYSICAL FOUNDATIONS*NO #*IEEE TRANS. ANTENNAES AND PROP., 547-566*JULY 1966*NO #*PRECIPITATION HAS BECOME A SERIOUS SOURCE OF ATTENUATION AS HIGHER FREQUENCIES ARE BEING EMPLOYED FOR MICROWAVE COMMUNICATIONS. SYSTEM PERFORMANCE IS STRONGLY INFLUENCED BY THE QUANTITY AND CHARACTER OF PRECIPITATION THAT OCCURS OVER THE LINKS OF THE SYSTEM. RAIN APPEARS TO BE THE PRECIPITATION FORM THAT ACCOUNTS FOR MOST OF THE SERIOUS ATTENUATION OCCURRENCES. IT IS ALSO FOR RAIN THAT THE SCATTERING THEORY IS MOST COMPLETE. RAIN ATTENUATION CAN BE ACCURATELY PREDICTED IF THE DROP SIZE DISTRIBUTION ALONG THE PROPAGATION PATH IS KNOWN. THESE DATA HAVE BEEN USED TO FORMULATE STATISTICAL RAINCELL MODELS THAT PERMIT PREDICTION OF THE PERFORMANCE OF SINGLE-PATH AND PATH-DIVERSITY SYSTEMS. THE CURRENT STATUS OF RAINCELL MODELS IS REVIEWED AND SUGGESTIONS FOR FUTURE RESEARCH ARE OFFERED. 59 REFERENCES.**

B12281D*CHAMBERS, J.G.; PHILLIPS, M.J.; BARNES, A.J.; AND ORVILLE-THOMAS, W.T.*ANALYSIS OF INFRARED BAND SHAPES DERIVED FROM ATTENUATED TOTAL REFLECTION (ATR) MEASURE-

MENTS*NO #*ADV. MOL. RELAXATION PROCESSES, VOL. 7, 113-120*1975*NO #*OPTICAL CONSTANTS MEASURED BY THE ATTENUATED TOTAL REFLECTION (ATR) TECHNIQUE FOR MEDIUM INTENSITY ABSORPTION OF A WIDE VARIETY OF LIQUIDS WERE USED TO TEST THE APPLICABILITY OF THE VAN VLECK-WERSSKOPFBOND SHAPE MODEL. THIS MODEL YIELDS TWO PARAMETER CHARACTERISTICS OF A PARTICULAR BOND, THE INTEGRATED BAND INTENSITY CORRECTED FOR THE BULK DIELECTRIC EFFECT AND A DAMPING CONSTANT, RELATED TO THE MEAN COLLISION OR RELAXATION TIME.**

B12587D*GIESE, K.*ON THE NUMERICAL EVALUATION OF THE DIELECTRIC RELAXATION TIME DISTRIBUTION FUNCTION FROM PERMITTIVITY DATA*NO #*ADVAN. MOL. RELAXATION PROCESSES, 5, 363-373*1973*NO #*IN THE LINEAR RESPONSE THEORY, A DESCRIPTION OF THE MACROSCOPIC DIELECTRIC PROPERTIES OF MATERIALS IS PROVIDED BY SOME CHARACTERISTICS FUNCTIONS, EACH OF WHICH COMPLETELY DETERMINES THE BEHAVIOR OF THE MATERIAL. DEPENDING ON THE KIND OF EXPERIMENT, PERFORMED EITHER IN THE FREQUENCY OR TIME DOMAIN, THE MEASUREMENTS ARE DISCUSSED IN TERMS OF THE COMPLEX PERMITTIVITY OF IN TERMS OF THE PULSE OR STEP RESPONSE POSITION. DISCUSSION IS MADE OF EMISSION CALCULATIONS OF E(W) FROM FOURIER TRANSFORM SPECTROMETERS USING THE FFT. 22 REFS.**

B12586C*DEV, S.B.; NORTH, A.M.;AND PETHRICK, R.A.*COMPUTATIONAL TECHNIQUES IN THE ANALYSIS OF DIELECTRIC RELAXATION MEASUREMENTS*NO #*ADVANCED MOL. RELAXATION PROCESSES, 4, 259-191*1972*NO #*IN THIS ARTICLE, A NUMBER OF COMPUTATIONAL TECHNIQUES CURRENTLY USED IN THE ANALYSIS AND INTERPRETATION OF DIELECTRIC DATA ARE DISCUSSED. PARTICULAR ATTENTION IS PAID TO NEW OR UNFAMILIAR PROCEDURES. THESE TECHNIQUES, ALTHOUGH THEY ARE CONSIDERED SPECIFICALLY IN TERMS OF DIELECTRIC MEASUREMENTS, MAY EQUALLY WELL BE APPLIED TO ANALOGOUS STUDIES OF THE MACROSCOPIC RESPONSE OF A SYSTEM TO A PERTURBING FIELD. (AVERAGE-.01-90 GHZ). 81 REFS.**

521181A*GIMMESTAD, G.G.; WARE, R.H.; BOHLANDS, R.A. AND GEBBIE, H.A.*OBSERVATION OF ANOMALOUS SUB MM ATMOSPHERIC SPECTRA*NO #*ASTROPHYSICAL JOURNAL, PART I, VOL. 208, 311-313*NOV 15, 1977*NO #*ATMOSPHERIC SPECTRA IN THE RANGE 7-25 CM-1 HAVE BEEN OBSERVED AT MT. EVANS, COLO. LARGE DISCREPANCIES ARE FOUND BETWEEN THE OBSERVATION AND A MODEL BASED ON KNOWN ATMOSPHERIC CONSTITUENTS. TO ACCOUNT FOR THIS, THE EXISTENCE IN THE ATMOSPHERE OF VAPOR PHASE COMPLEXESOF WATER MOLECULES ASSOCIATED WITH CERTAIN WEATHER PHENOMENA IS POSTULATED.**

C43111A*CORCORAN, VINCENT J.*FAR-INFRARED-SUBMILLIMETER PHASED ARRAYS AND APPLICATIONS*NO #*IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUE, VOL. MTT-22, NO. 12, 1103-1107*DEC 1974*NO #*THIS IS A TWO-PART ARTICLE: THE FIRST PART DISCUSSES THE "ANTENNA PATTERNS OF A PHASED ARRAY OF SUBMM DEVICES, USING THE FOURIER TRANSFORM OF THE APERTURE PATTERN. THE SECOND PART GIVES, IN 3 TABLES, "WINDOWS IN THE SUBMM AND MM ATMOSPHERIC ABSORPTION SPECTRUM, AND ATTENUATIONS DUE TO CLOUDS. SOME APPLICATIONS OF THE MM WAVEBAND ARE DISCUSSED.**

622181I*LIEBE, H.J. AND WELCH, W.M.*MOLECULAR ATTENUATION AND PHASE DISPERSION BETWEEN 40 AND 140 GHZ FOR PATH MODELS FROM DIFFERENT ALTITUDES*NO #*OFFICE OF TELECOMMUNICATIONS, N.B.S. OT REPORT 73-10*MAY 1973*NO #*RADIO WAVE PROPAGATION IN THE 40 - 140 GHZ BAND THROUGH THE FIRST 100 KM OF THE ATMOSPHERE I STRONGLY INFLUENCED BY THE MICROWAVE SPECTRUM OF OXYGEN (O2-MS). A UNIFIED TREATMENT OF MOLECULAR ATTENUATION AND PHASE DISPERSION IS FORMULATED. RESULT OF MOLECULAR PHYSICS ARE TRANSLATED INTO FREQUENCY, TEMPERATURE, PRESSURE, AND MAGNETIC FIELD DEPENDENCIES OF A COMPLEX REFRACIVE INDEX. THE INFLUENCE OF WATER VAPOR IS ALSO DISCUSSED. ATTENUATION AND DISPERSION RATES FOR PATH MODELS ARE EVALUATED BY COMPUTER ROUTINES. EXAMPLES OF COMPUTER PLOTS ARE GIVEN AS A FUNCTION OF ALTITUDE FOR HOMOGENEOUS, ZENITH, AND TANGENTIAL PATH GEOMETRIES. MOLECULAR RESOURCES OF MINOR ATMOSPHERIC GASES ARE DISCUSSED BRIEFLY AS IN THE NOISE WHICH ORIGINATES FROM THE O2-MS.**

812583K*RUDASHEVSKY, E.G.; PROKHOROV, A.S.; AND VELIKOV, L.V.* SUBMILLIMETER SPECTROSCOPY OF WEAK ANTIFERROMAGNETO IN MAGNETIC FIELDS UP TO 300 KOE*NO #*IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. MTT-22, NO. 12, 1064-1069*DEC 1974*NO #*THE DYNAMIC PROPERTIES OF ANTIFERROMAGNETS WITH DZYALOSHINKY INTERACTION WERE INVESTIGATED AT WAVELENGTH 0.3-14 MM, IN MAGNETIC FIELDS UP TO 300 KOE AND AT TEMPERATURE 4.2-400 DEG K. THE PROBLEM OF IMPURITIES, FIELD-INDUCED PHASE TRANSITIONS, TYPES OF SPIN OSCILLATION FOR DIFFERENT TYPES OF ANTI-FERROMAGNET WITH DZYALOSHINKLY INTERACTION ARE DISCUSSED. BASED ON THE INVESTIGATION RESULTS, A NEW APPROACH TO THE PHYSICS OF MAGNETIC PHENOMENON, USING THE COMPLETE RATIONAL BASIS OF MOMENT AND AVOIDING POTENTIAL SERIES EXPANSION, HAS BEEN DEVELOPED. COMPARISONS OF AFMR EXPERIMENT AND THEORY FOR ALPHA - FE2O3 (BLACK IRON OXIDE-ALPHA HEMATITE), NI, F2, FEBO3, DOPER/ FEBO30(WITH GA+3), ARE GIVEN, AND CORRELATION IS EXCELLENT.**

133182L*KUKIN, L.M.; NOZDRIN, YU.N.; RYADOV, V.YA; FEDOSEYEV, L.I.; AND FURASHOV, N.I.*DETERMINATION OF THE CONTRIBUTION OF WATER VAPOR MONOMERS AND DIMERS TO ATMOSPHERIC ABSORPTION FROM MEASUREMENT DATA IN THE LAMBDA = 1,15-1.55 MM BAND*NO #*RADIO ENGINEERING AND ELECTRONIC PHYSICS, VOL. 20, NO. 10, 7-13*OCT 1975* NO #*THE COMPONENT OF THE WATER VAPOR ABSORPTION COEFFICIENT THAT ARE LINEARLY AND QUADRATICALLY DEPENDENT ON THE ABSOLUTE HUMIDITY OF THE AIR ARE DETERMINED FROM MEASUREMENTS OF THE DEPENDENCE OF RECEIVED RADIATION ON THE LATTER. THE LINEAR COMPONENT TOGETHER WITH A CERTAIN PORTION OF THE QUADRATIC ARE TAKEN INTO CONSIDERATION THE SELF BROADENING OF THE LINES OF THE H2O MONOMERS IS IDENTIFIED WITH THE ABSORPTION COEFFICIENT OF THE MONOMERS: THE REST OF THE QUADRATIC COMPONENT IS IDENTIFIED WITH THE ABSORPTION COEFFICIENT OF THE DIMENS. THIS PAPER CONTAINS THE RESULTS OF TWO INDENPENDENT EXPERIMENTS, PRESENTED AT THE RUSSIAN (ALL-UNION)

SYMPOSIUM ON THE PROPAGATION OF SUB MM AND MM WAVES IN THE ATMOSPHERE IN 1974. THERE ARE 41 REFERENCES.**

5211817*GORDY, WALTER; SMITH, WM. V.; AND TRAMBANLO, RALPH. F.*MICROWAVE SPECTROSCOPY*NO #*JOHN WILEY*1953*NO #*THIS IS AN EARLY TEXTBOOK ON MICROWAVE SPECTROSCOPY; A LOT OF THE RESONANCE AND ABSORPTION LINES (IN THE 30-300 GHZ) OF BARE ATMOSPHERE CONSTITUENTS WERE DISCOVERED BY USE OF TECHNIQUES DESCRIBED IN THE BOOK. IT IS A STANDARD REFERENCE.**

521781C*WACKER, PAUL F. ; CORD, MARIAN S., ET AL.*SPECTRAL TABLES, VOL. III. POLYATOMIC MOLECULES WITH INTERNAL ROTATION*NO #*N.B.S. MONOGRAPH 70, VOL. III*JUNE 1969*NO #*THIS IS A PART OF THE 5-VOLUME NBS MONOGRAPH SERIES ON MICROWAVE SPECTRAL TABLES. THESE ARE OF VALUE FOR DETERMINING CHEMICAL CONSTITUENCY OF A SPECIFIC MOLECULAR SPECIES -- SUCH AS OIL VAPORS, COMBUSTION PRODUCTS -- IN THE SPECTRAL REGION FOR 5 GHZ TO PAST 50 GHZ. OTHER VOLUMES IN THIS NBS TABLES SERIES ARE: I. DISTANCE MOLECULES; II. LINE STRENGTHS OF ASYMMETRIC ROTATIONS; IV. POLYATOMIC MOLECULES WITHOUT INTERNAL ROTATION; V. SPECTRAL LINE LISTING.**

5317618*CARLI, B.; MARTIN, D.H.; PUPLET, E.F.; AND HARRIES, J.E.*VERY HIGH RESOLUTION FOR I.R. MEASUREMENTS OF ATMOSPHERIC EMISSION FROM AIRCRAFT*NO #*J. OPT. SOC. AM., VOL. 67, NO. 7, 917-921*JULY 1977*NO #*AN ABSOLUTE SPECTROMETRIC RADIOMETER HAS BEEN FLOWN ON A NASA-CV940 AIRCRAFT TO MEASURE ATMOSPHERIC EMISSION IN THE SPECTRAL RANGE 5-40 CM-1 WITH A RESOLUTION OF 0.02 CM-1 APODIZED. THE INSTRUMENT AND THE RESULTS ARE DESCRIBED.**

5417A1C*YAMONOLA, MASANOBA*OPTICALLY PUMPED WAVEGUIDE LASERS*NO #*J. OPT. SOC. AM., VOL. 67, NO. 7, 952-958*JULY 1977*NO #*OPTICALLY PUMPED WAVEGUIDE GAS LASERS IN THE SUB MM AND MM WAVE REGIONS ARE SIMPLE, COMPACT, RUGGED, EFFICIENT, PRACTICAL COHERENT SOURCES. A NUMBER OF NEW LASER LINES HAVE BEEN OBSERVED IN THESE LASERS. GENERAL CONSIDERATIONS ARE GIVEN ON THE ATTENUATING CONSTANTS OF THE WAVEGUIDES AND THE RATE EQUATION MODELS. CHARACTERISTICS OF THESE LASERS ARE REVIEWED INCLUDING OUTPUT COUPLING, NEW LASER LINE, MODE, POLARIZATION, OUTPUT POWER, STABILITY AND COMPACTION. SOME APPLICATIONS ARE DESCRIBED BRIEFLY. FINALLY, FUTURE ASPECTS ARE DISCUSSED.**

951181M*BEAN, B.L. AND PERKOWITZ, S.*SUB MM FAR IR SPECTROSCOPY IN THE LIQUID AND SOLID STATE WITH A TUNABLE OPTICALLY PUMPED LASER*NO #*J. OPT. SOC. AM., VOL. 67, NO. 7, 911-914*JULY 1977*NO #*THE DESIGN AND SPECTROSCOPIC APPLICATION OF A SUBMILLIMETER-FAR-INFRARED (FIR) OPTICALLY PUMPED TUNABLE LASER ARE DESCRIBED. DRIVEN BY 15-25 W OF POWER FROM A CW CO2 LASER, THE FIR SYSTEM GAVE MILLIWATTS OF POWER BETWEEN 96 AND 1217 UM. THE PUMPED MEDIA WERE METHYL ALCOHOL (CH3OH) AND 1,1-DIFLUOROETHYLENE (CH2CF2). THE LASER SPECTROMETER WAS USED TO MEASURE THE TRANSMISSION OF LIQUID H2O, THE BULK SEMICONDUCTOR GAAS, THE EPITAXIAL SEMICONDUCTOR INAS, AND THE HIGH-TEMPERATURE SUPERCONDUCTOR V3SI. IN GENERAL, THE LASER SYSTEM GAVE VASTLY IMPROVED SIGNAL-TO-NOISE RATIOS, REDUCED STRAY LIGHT PROBLEMS, AND

INCREASED PENETRATION POWER RELATIVE TO MORE CONVENTIONAL FIR SPECTROMETERS. THE LASER RESULTS AGREED EXTREMELY WELL WITH RESULTS FROM CONVENTIONAL SPECTROMETERS EXCEPT WHERE THE NARROWNESS OF THE LASER LINE PRODUCED INTERFERENCE EFFECTS. THIS SYSTEM SHOULD BE A USEFUL TOOL IN THE MEASUREMENT OF THE OPTICAL CONSTANT OF DUST AND SOLIDS THAT MAKE UP AEROSOLS.**

5221819*RAO, K. NARAKARI, EDITOR*MOLECULAR SPECTROSCOPY; MODERN RESEARCH, VOL. 2*NO #*ACADEMIC PRESS, N.Y.*1976*NO #*THIS VOLUME GIVES INSIGHT INTO THE RESEARCH IN SEVERAL AREAS OF THE SPECTROSCOPY OF GASES. THE TOPICS COVERED ARE LEAST SQUARES FITTING OF SPECTROSCOPIC DATA, SUB MM SPECTROSCOPY, THE RENVER-TELLER EFFECT, INTERESTS FROM I.R. SPECTRA, "FORBIDDEN" ROTATIONAL TRANSACTIONS, THE DIFFUSE INTERSTELLAR LINES, AND LONG-LIVED ENERGETIC PRODUCTS OF CHEMICAL REACTION.**

551761B*GROMOV, V.D.; SHOLOMITSKIY, G.B.; SOGLOSNOVA, V.A.; AND ARTAMONOV, V.V.*AN AIRBORNE SUB MM RADIOMETER WITH REMOVABLE SPECTRAL FILTERS FOR THE STUDY OF ATMOSPHERIC EMISSIONS IN THE 50-1000 UM REGION*NO #*ACADEMY OF SCIENCES USSR, INSTITUTE OF SPACE RESEARCH, MOSCOW REPORT PR-250, NASW-2791*JUNE 1976*N76-24528*A DESCRIPTION IS GIVEN OF THE FLIGHT TEST OF A RADIOMETER WITH REMOVABLE SPECTRAL FILTERS. THIS RADIOMETER MADE IT POSSIBLE TO OBTAIN THE SPECTRAL AND ANGULAR DISTRIBUTION OF THE ATMOSPHERE RADIATION TEMPERATURE. THE EQUIPMENT IS ILLUSTRATED IN FIGURES AND DISCUSSED IN DETAIL.**

512611H*EICHLER, M.*ATMOSPHERIC EFFECTS ON ELECTROMAGNETIC WAVE PROPAGATION IN MM, CM, AND DM WAVELENGTHS, PART I. RAY DEFLECTION*NO #*NO #*JUNE 1974*N76-22433*MODELS ARE PRESENTED FOR THE REFRACTIVE INDEX WHICH RESULTS AS A FUNCTION OF HEIGHT OF BAROMETRIC PRESSURE, TEMPERATURE, AND HUMIDITY FOR THE TROPOSPHERE AND THE IONIZATION FOR THE IONOSPHERE. FURTHERMORE, A SURVEY IS GIVEN ON THE DIFFERENT WAYS TO ACQUIRE PROPAGATION ERRORS. WHEREBY NOT ONLY EXACT SOLUTIONS ARE CONSIDERED, BUT ALSO APPROXIMATE RESULTS. BOTH WERE OBTAINED WITH LITTLE CALCULATION EFFORT. BY WAY OF AN ITERATIVE DETERMINATION OF THE TARGET HEIGHT, IT IS POSSIBLE TO ASCERTAIN ANGLE AND RANGE ERRORS FROM RADAR DATA (DISTANCE, ELEVATION, ANGLE). WITH EXAMPLES FOR THE CRPL-EXPONENTIAL ATMOSPHERE, THE INFLUENCE OF THE REFRACTIVE INDEX, REFRACTIVE INDEX GRADIENT, AND ELEVATION ANGLE ON THE REFRACTIVE ANGLE, ANGLE AND RANGE ERRORS ARE INVESTIGATED.**

512612C*MEYERS, R.*ATMOSPHERIC EFFECTS ON ELECTROMAGNETIC WAVE PROPAGATION IN MM, CM, AND DM WAVELENGTHS, PART 2. (IN GERMAN)*NO #*NO #*JUNE 1974*N76-22434*THIS PAPER DEALS WITH THE WAVE PROPAGATION IN THE REAL ATMOSPHERE, PARTICULARLY THE ATTENUATION CAUSED BY ABSORPTION AND DISPERSION OF E & M RADIATION. THEREBY, THE INFLUENCE OF GASES IS INVESTIGATED (WATER VAPOR & O2), PRECIPITATION (RAIN, SNOW, HAIL), CLOUDS AND FOG. BEYOND THIS, DIAGRAMS AND CALCULATION METHODS ARE CITED, WITH THE AID OF WHICH, THE PROPAGATION PATHS OF WAVES IN A DIAGONAL DIRECTION, AS A FUNCTION OF HEIGHT CAN BE CAL-

CULATED. 57 REFS.**
511172 *IPPOLITO, L.J.*TWENTY AND THIRTY GHZ MILLIMETER WAVE EXPERIMENTS WITH ATS6 SATELLITE*NASA TN D-8197*NO #* APRIL 1976*N76-22424*THE APPLICATIONS TECHNOLOGY SATELLITE-6(ATS-6) MM WAVE EXPERIMENT DEVELOPED AND IMPLEMENTED BY THE NASA GODDARD SPACE FLIGHT CENTER (GSFC) PROVIDES THE FIRST DIRECT MEASUREMENTS OF 20 AND 30 GHZ EARTH-SPACE LINKS FROM AN ORBITING SATELLITE. STUDIES AT 11 LOCTIONS IN THE CONTINENTAL U.S. WERE DIRECTED AT AN EVALUATION OF RAIN ATTENUATION EFFECTS, SCINTILLATIONS, DEPOLARIZATIONS, SITE DIVERSITY, COHERENCE BANDWIDTH, AND ANALOG AND DIGITAL COMMUNICATIONS TECHNIQUES. IN ADDITION TO DIRECT MEASUREMENTS WITH RADARS, RAIN GAUGES, AND RADIOMETERS WERE DEVELOPED AND COMPARED WITH THE DIRECTLY MEASURED ATTENUATION. THIS REPORT CONTAINS THE FIRST COMPREHENSIVE PUBLICATION OF INITIAL DATA RESULTS OF THE ATS-6 MM WAVE EXPERIMENT FROM THE MAJOR PERLICOMPUTING ORGANIZATIONS.**
132181A*ZRAZHEVSKIY, A.YU.*METHOD OF CALCULATING THE ATMOSPHERIC WATER VAPOR ABSORPTION OF MILLIMETER AND SUBMILLIMETER WAVES*NO #*RADIO ENGINEERING AND ELECTRONIC PHYSICS, VOL. 21, NO. 5, 31-36*MAY 1976*NO #*A METHOD OF SEMI-EMPIRICALLY CALCULATING THE SPECTRAL REGION. 74 CM-1 TO 12 CM-1 (1.35 CM TO .083 CM) IS PRESENTED. THE SMALL EFFECT OF THE DIMERS OF WATER IS NOT INCLUDED. IN THE COMPARISON OF THE ABSORPTION OF WATER VAPOR IN DB/KM VS WAVE NUMBER, THE EMPIRICAL FORMULA AGREES RATHER CLOSELY WITH EXPERIMENT.**
B11411N*WANG, R.T. AND GREENBERG, J.M.*SCATTERING BY SPHERES WITH NONISOTROPIC REFRACTIVE INDICES*NO #*APPLIED OPTICS, VOL. 15, NO. 5, 1212-1217*MAY 1976*NO #*THIS ARTICLE COVERS X-BAND SCATTERING OFF OF TWO SETS OF ARTIFICIAL ANISOTROPIC DIELECTRIC SPHERES MADE OF LAYERS OF CARBON PAPER, ROYAL GRAY PAPER AND PARAFFIN BONDED TOGETHER BY THE APPLICATION OF HEAT AND PRESSURE. ANISOTROPIC MEDIA OF THE SECOND GROUP WERE PREPARED FROM ALTERNATE LAYERS OF EXPANDED POLYSTYRENE AND A CONDUCTING PAPER CALLED TELEDELTO. THREE TARGETS IN THE SIZE RANGE 2.58 LE X = KN LE 5.68, A = RADIUS WER CONSTRUCTED FOR EACH TYPE OF ANISOTROPY. THE PRINCIPLE REFRACTIVE INDICES MK, ME, AND MH FOR THE SYMMETRY AX IS PARALLEL TO KO, EO, AND HO OF THE INCIDENT WAVE RESPECTIVELY, WERE MEASURED FOR EACH GROUP. RESULTS SHOW THAT MIE THEORY PREDICTION USING AN EFFECTIVE REFRACTIVE INDEX AT EACH FORGED ORIENTATION IS A GOOD APPROXIMATION FOR ANISOTROPIC SPHERES IN THE FORWARD SCATTERING STUDIES. WHEN THE SYMMETRY AX IS PARALLEL TO THE POLARIZATION, FOR WHICH CASE THE MOST PRECISE REFRACTIVE INDEX DETERMINATION IS POSSIBLE, THE AGREEMENT IS EXCELLENT. THE AGREEMENT DEGRADES PROGRESSIVELY AS ONE GOES TOWARD OTHER PRINCIPLE DIRECTIONS.**
542121D*TRAUB, WESLEY A. AND STIER, MARK T.*THEORETICAL ATMOSPHERIC TRANSMISSION IN THE MID AND FAR INFRARED AT FOUR ALTITUDES*NO #*APPLIED OPTICS, VOL. 15, NO. 2, 364-377*FEB 1976*NO #*THE IR TRANSMISSION OF THE TERRESTRIAL ATMOSPHERE IS CALCULATED AT FOUR ALTITUDES OF INTEREST, 4.2 KM (2-1000 UM), 14 KM (5-1000 UM), 28 AND

41 KM (10-1000 UM). BOTH HIGH RESOLUTION SPECTRA (.05 CM-1) AND BROADBAND AVERAGES ARE SHOWN. THE MODEL ATMOSPHERE USED IS A SINGLE LAYER CARTER GODSON APPROXIMATION WITH THE COLUMN ABUNDANCES GIVEN ACCORDING TO ALTITUDE. THE ABSORPTION LINE PROFILE IS A CONVOLUTION OF A LORENTZIAN AND A GAUSSIAN. THERE ARE 23 REFERENCES TO SOURCE ARTICLES IN ATMOSPHERIC LIGHT TRANSMISSION.**

111161I*LONGBOTHEM, RICHARD L.*A FEASIBILITY STUDY OF A MICROWAVE WATER VAPOR MEASUREMENT FROM A SPACE PROBE ALONG AN OCCULTATION PATH*NO #*PENNSYLVANIA STATE UNIVERSITY* APRIL 1975*N75-29603*THIS IS AN EXPERIMENTAL AND THEORETICAL STUDY ON THE FEASIBILITY OF USING A MM WAVE RADIOMETER TO MEASURE THE WATER VAPOR CONTENT ALONG ITS LINE OF SIGHT PATH AT 22 (22.235) GHZ AND 183(183.31) GHZ. THE RESONANT H2O CROSS SECTIONS ARE PRESENTED, AND USED TO MODEL THE ATMOSPHERIC WATER VAPOR. RADIOMETER SENSITIVITY IS COMPARED WITH CALCULATED OPTICAL DEPTHS TO DETERMINE THE HEIGHT TO WHICH A RADIOMETER CAN MEASURE WATER VAPOR, USING THE THREE METHODS -- PASSIVE ABSORPTION PASSIVE EMISSION, AND ACTIVE ABSORPTION. CONCLUSION: MEASUREMENTS WITH THE 22 GHZ LINE ARE LIMITED TO 50 KM THICKNESS: USE OF THE 183 GHZ LINE WILL ENABLE MEASUREMENTS UPTO AND ABOVE 100 KM FOR WATER VAPOR MIXING RATIOS AS LOW AS 0.1 PPM UNDER OPTIMUM CONDITIONS. THIS ARTICLE CONTAINS AN EXCELLENT DISCUSSION ON MICROWAVE RADIOMETERS.**

2315419*AFSAR, M.N. AND HARTED, J.B.*MEASUREMENTS OF THE OPTICAL CONSTANTS OF LIQUID H2O AND D2O BETWEEN 6 AND 450 CM-1*NO #*J. OPT. SOC. AM., VOL. 67, NO. 7, 902-904* JULY 1977*NO #*VARIOUS ADVANCES IN TECHNIQUES HAVE ENABLED NEW MEASUREMENTS TO BE MADE OVER A GREATLY EXTENDED FREQUENCY RANGE (6 LT V LT 450 CM-1) OF THE OPTICAL CONSTANTS N(V) AND ALPHA (V) OF LIQUID WATER AND LIQUID D20 OF 19 DEG C. THE ORIGIN OF THE POLARIZATION IN THIS REGION IS DISCUSSED.**

531131B*GOLDSMITH, PAUL F.; PLAMBECK, RICHARD L.; AND CHIAD, RAYMOND L.*MEASUREMENT OF ATMOSPHERIC ATTENUATION AT 1.3 AND 0.87 MM WITH AN HARMONIC MIXING RADIOMETER*NO #* IEEE MT-22, NO. 2, 1115-1116*DEC 1974*NO #*THE ATMOSPHERIC ATTENUATION AT 1.3 AND 0.87 MM WAS MEASURED ABOVE M + MAMILTON, CALIF. DURING THE PERIOD DEC 5 TO DEC 9, 1973. THE MEASURED VALUE OF THE ZENITH ATTENUATION VARIED FROM 1 TO 5 DB AT 1.3 MM OVER THIS 5-DAY PERIOD AND WAS 2.5 DB AT 0.87 MM ON DEC 9, 1973. THE TOTAL BEAMWIDTH OF THE 120" LINK OBSERVATORY TELESCOPE USED IN THE CONDI CONFIGURATION WAS MEASURED TO BE 3' AT 1.3 MM.**

813761B*KONG, J.A., EDITOR*THEORY OF PASSIVE REMOTE SENSING WITH MICROWAVES, FINAL REPORT*CONTRACT NO. 953524*NO #* JULY 1975*N76-18629*THIS IS A COLLECTION OF PAPERS ON REMOTE SENSING OF THE EARTH BY MICROWAVES IN THE FREQUENCY RANGE 1.4-37 GHZ. KONG 'S ARTICLE TREATS THE FOLLOWING TOPICS: STRATIFIED MEDIA WITH UNIFORM TEMPERATURE DISTRIBUTION, 1/2 SPACE RANDOM MEDIA WITH NON-UNIFORM TEMPERATURE DISTRIBUTION, 2 LAYER RANDOMMEDIA WITH UNIFORM TEMPERATURE DISTRIBUTION AND STRATIFIED MEDIA WITH NON-UNIFORM TEMPERATURE DISTRIBUTION. REPORTS/THESIS

BY STUDENTS ARE IN APPENDICES TO THIS MAIN REPORT.**
511173G*HODGE, D.B.; THICKOLD, D.M.; AND TAYLOR, R.C.*ATS-6 MILLIMETER WAVELENGTH PROPAGATION EXPERIMENT*ESL 3863-6* NO #*JAN 1973*N76-19211*THIS REPORT SUMMARIZES THE OHIO STATE UNIVERSITY PARTICIPATION IN THE ATS-6 MM WAVE PROPAGATION EXPERIMENT. ATTENUATION WAS MEASURED SIMULTANEOUSLY AT 20 AND 30 GHZ ON EARTH-SPACE PROPAGATION PATHS TO TWO GROUND TERMINALS LOCATED AT COLUMBUS, OHIO. IN ADDITION, 20 AND 30 GHZ RADIOMETRIC TEMPERATURES WERE MEASURED ALONG THE SAME PROPAGATION PATHS; THE 30 GHZ RADIOMETRIC TEMPERATURE WAS ALSO MEASURED AT A 3RD GROUND TERMINAL. THE RESULTS OF THESE MEASUREMENTS ARE PRESENTED AND DIVERSITY GIVEN FOR THE FOUR PATHS ARE DISCUSSED. THE SCINTILLATION CHARACTERISTICS OF THE RECEIVED SIGNALS ARE ALSO PRESENTED. THE VARIANCE OF THE SCINTILLATIONS (IN CLEAR AIR) WERE FOUND TO BE PROPORTIONAL 11/6 POWER OF THE PATH LENGTH THROUGH THE ATMOSPHERE.**
9335818*SMYTH, CHARLES P.*RESEARCH ON DIELECTRIC PROPERTIES AND STRUCTURE OF MATTER; QUARTERLY STATUS REPORT* NONR-1858(09)*NO #*1965*AD-612 916*THIS THREE-MONTH REPORT DISCUSSES MM WAVE DIELECTRIC MEASUREMENTS AT 2 MM ON TOLNENE AND CHLOROBENZENE. MEASUREMENTS AT 3 KM AND 1 CM THAT WERE TO BE DONE LATER ARE DISCUSSED. RESULTS OF THE MEASUREMENTS MAY BE FOUND IN THE PUBLISHED SCIENTIFIC PAPERS LISTED IN THIS PROGRESS REPORT.**
211471E*BOSTIAN, C.W. AND STUTZMAN, W.L.*THE INFLUENCE OF POLARIZATION ON MILLIMETER WAVE PROPAGATION THROUGH RAIN; SEMI-ANNUAL STATUS REPORT*NGR-47-004-091*NO #*JULY 1972* N73-10217*THIS REPORT DESCRIBES A PROGRAM FOR THE MEASUREMENT AND ANALYSIS OF THE DEPOLARIZATION AND DIFFERENTIAL ATTENUATION THAT OCCUR WHEN MM WAVE SIGNALS PROPAGATE THROUGH RAIN. INITIAL DATA WILL BE TAKEN ALONG A 1.43 MM PATH AT 17.65 GHZ AND A SUPPORTING THEORETICAL MODEL WILL BE DEVELOPED TO RELATE THE PROPAGATION EFFECTS TO RAINFALL RATE AND WIND VELOCITY. POLARIZATION CHOSEN FOR THE INSUING EXPERIMENTS IS + OR - 45 DEG FROM THE VERTICAL. DEPARTURE FROM SPHERICITY OF RAINDROPS, OBLIQUE SCATTER, AND MULTIPLE SCATTER ALL CAUSE DEPOLARIZATION, WITH NON SPHERICITY THE MOST IMPORTANT FACTORS.**
1121835*MARTIN, D.H.*SPECTROSCOPIC TECHNIQUES FOR FAR IR, SUB MM AND MM WAVES*NO #*BOOK, NORTH HOLLAND PUBLISHING CO.,1967*QC 457 1427*THIS BOOK HAS A THOROUGH DISCUSSION OF TECHNIQUE FOR MAKING MEASUREMENTS IN THESE WAVE BANDS IN SOLIDS, LIQUIDS, AND GASES, CA 1967.**
1121825*STEELE, DEREK*THEORY OF VIBRATIONAL SPECTROSCOPY* NO #*BOOK, W.B. SAUNDERS CO.*1971*QC 454 V5 574*TEXTBOOK ON PHYSICS ON MOLECULAR VIBRATORS; APPLICATION TO MM AND MICROWAVE SPECTROSCOPY. IT HAS A GOOD DISCUSSION ON SOLVING THE SECULAR EQUATION FOR MOLECULAR DYNAMICS.**
1131117*KERR, DONALD E.; EDITOR*PROPAGATION OF SHORT RADIO WAVES*NO #*MIT RAD LAB SERIES #13, MCGRAW HILL* 1951*NO #*THIS IS A PIONEER PUBLISHING EFFORT ON PROPAGATION OF SHORT RADIO WAVES DONE BY THE MEMBERS OF THE PROPAGATION GROUP AT MIT DURING WORLD WAR II. THIS MUST BE CONSIDERED ONE OF THE SOURCE BOOKS FOR MM PROPAGA-

TION.**
112181K*AGANBEKYAN, K.A.; ZRAZHEVSKIY, A.YU.; AND MOLINHIN, V.G.*TEMPERATURE DEPENDENCE OF THE ABSORPTION OF RADIO WAVES BY ATMOSPHERIC WATER VAPOR AT THE 10 CM-0.27 MM WAVELENGTHS*NO #*RADIO ENGINEERING AND ELECTRONIC PHYSICS, 20, NO. 11*NOV 1975*NO #*THE ABSORPTION COEFFICIENTS IN THE .398-13.5 MM WAVELENGTH REGION WATER VAPOR ARE CALCULATED FOR CONSTANT AIR PRESSURE AND RELATIVE WATER VAPOR CONCENTRATION FOR TEMPERATURES OF 173-373 DEG K. FROM THE RESULTS OF THIS CALCULATION, THE TEMPERATURE DEPENDENCE OF THE ABSORPTION IS OBTAINED AT WAVELENGTHS IN THE CM, MM AND SUB MM BANDS, AND CAN BE REPRESNTED IN THE FORM GAMMA IS PROPORTIONAL TO T-N1. THE TEMPERATURE COEFFICIENT N1 LIES WITHIN THE INTERVAL FROM 3.2 TO 4 IN THE TRANSMISSION WINDOWS, AND DECREASES TO 1-2 IN THE ABSORPTION LINES. THE CALCULATION AGREES WELL WITH EXPERIMENTAL DATA. THE PRINCIPAL INACCURACY IN THE CALCULATION IS DUE TO THE INDETERMINING OF THE 1/2 WIDTH OF THE ABSORPTION LINES, FOR RADIATION IN THE .398 MM TO 13.5 MM BAND.**
622171A*LIEBE, HANS J.*MOLECULAR TRANSFER CHARACTERISTICS OF AIR BETWEEN 40 AND 140 GHZ*NO #*IEEE TRANS MICROWAVE THEORY AND TEHCNIQUES MTT-23, NO. 4, 380-386*APRIL 1975* AD-A012 256*RADIO WAVE PROPAGATION IN THE 40-140 GHZ BAND THRU THE FIRST 100 KM OF THE CLEAR ATMOSPHERE IS INFLUENCED BY 30 LINES OF O2 SPECTRUM, AND A LASER EXTENT BY WATER VAPOR. A UNIFIED TREATMENT OF MOLECULAR ATTENUATION AND PHASE DISPERSION IS FORMULATED WHEREBY RESULTS OF MOLECULAR PHYSICS ARE TRANSLATED INTO FREQUENCY, PRESSURE AND TEMPERATURE DEPENDENCES.**
532182B*HARRIS, J.E.*ATMOSPHERIC TRANSMISSION IN SEVERAL SUBMILLIMETER WINDOWS*NO #*INFRARED PHYSICS, VOL. 16, 483-485*1976*NO #*THIS IS A PRESENTATION OF A CALCULATION OF THE TRANSMISSION IN SEVERAL ATMOSPHERIC WINDOWS BETWEEN 5 AND 95 CM-1 FOR VARIOUS OBSERVATIONAL GEOMETRIES COVERING MANY CASES ARISING IN PRACTICAL ASTRONOMICAL AND ATMOSPHERIC EXPERIMENTS. THE TRANSMITTANCE AT A WAVENUMBER GAMM(=1/LAMBDA) BETWEEN A HEIGHT H IN THE ATMOSPHERE AND OUTSIDE THE ATMOSPHERE, IN A DIRECTION THETA TO THE ZENITH, HAS BEEN CALCULATED AS A FUNCTION OF THE WATER VAPOR CONTENT ALONG THE LINE OF SIGHT.**
142121B*RIGHINI, G. AND SIMON, M.*EXTINCTION IN THE SUB-MILLIMETER ATMOSPHERIC WINDOWS*NO #*INFRARED PHYSICS, VOL. 16, 543-554*1976*NO #*THE PROBLEM OF THE EXTINCTION COEFFICIENT FOR GROUND BASED SUB MM ASTRONOMY IS DISCUSSED. MODEL CALCULATIONS (FOR WATER VAPOR) SHOW THAT THE EXTINCTION MAY BE APPROXIMATED BY THE FUNCTION EXP(-ALPHA X)/SQUARE ROOT ALPHA X, WHERE X IS THE LINE OF SIGHT WATER VAPOR COLUMN DENSITY, MEASUREMENTS OF THE EFFECTIVE ABSORPTION COEFFICIENTS IN THE ATMOSPHERIC WINDOW OF 450 UM, 625 UM, 714 UM, AND 1 MM REGION, RELATIVE TO THAT AT 350 UM ARE PRESENTED.**
B33561N*RED'KIN, B.A.; KLOKKO, V.V.; KHOKHLACHEZE, V.V; AND BABUSHKIN, A.G.*THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE COMPLEX DIELECTRIC CONSTANT OF GROUND

IN THE USW BAND (3 CM)*NO #*RADIO ENGINEERING AND ELECTRONIC PHYSICS, VOL. 20, NO. 1, 111-112*JAN 1975*NO #*THE INVESTIGATIONS CONDUCTED BY US INDICATED THAT THE COMPLEX DIELECTRIC OF THE GROUND EXPERIENCES LARGE CHANGES WITH HUMIDITY, TEMPERATURE AND SIGNAL FREQUENCY. THE RESULTS HAVE A SIMPLE EXPLANATION IF THE GROUND IS REGARDED AS A COMPLEX DIELECTRIC THAT CONSISTS OF DRY EARTH AND WATER THAT CONTAINS A MIXTURE OF DISSOLVED SALTS. THE DIELECTRIC CONSTANT OF DRY EARTH CAN BE THEN ASSUMED AS BEING REAL AND INDEPENDENT OF FREQUENCY AND THE DIELECTRIC PROPERTIES OF WATER ARE DESCRIBED BY THE DEBYE RELAXATION FORMULA, WITH A CONSIDERATION OF THE IONIC CONDUCTIVITY OF THE DISSOLVED SALTS. WITH THIS APPROACH WE CAN USE THE KNOWN DEPENDENCE OF THE ELECTRICAL PROPERTIES OF WATER ON THE RADII WAVELENGTH, THE TEMPERATURE, AND THE CONCENTRATION OF SALTS IN ORDER TO COMPUTE THE VALUE OF THE COMPLEX DIELECTRIC CONSTANT OF THE REAL PHYSICAL GROUND. CALCULATIONS MATCH MEASUREMENTS REASONABLY GOOD AT 3 CM WAVELENGTH.**

B41261B*BLUE, M.D. AND PERKOWITZ, S.*REFLECTIVITY OF COMMON MATERIALS IN THE SUBMILLIMETER REGION*NO #*IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES,VOL. MTT-25, NO. 6, 491-493*JUNE 1977*NO #*THE APPEARANCE OF AN ILLUMINATED SCENE AS SUB MM WAVELENGTHS IS DETERMINED BY SURFACE REFLECTIVITY. REFLECTIVITIES OF SOME MANMADE AND NATURAL MATERIALS (GRASS, BLACK PAINT, RUST, SAND, SOIL, WOOD (OAK, MAHOGANY, FIR AND ROSEWOOD), LEAVES (MAPLE AND GRASS, BOTH FRESH AND DRY), ASPHALT, CONCRETE) HAVE BEEN MEASURED. THE RESULTS PROVIDE SOME INSIGHT FOR EVALUATING POSSIBLE APPLICATIONS OF SUB MM RADIATION.**

511175C*VOGEL, W.J.; STRACTON, A.W.; WAGNER, N.K.; AND FANNIN, B.M.*ATS-6 ATTENUATION DIVERSITY MEASUREMENTS AT 20 AND 30GHZ*CONTRACT NAS5-21982*NO #*NOV 1975*N76-13333*THE RESULTS OF DATA OBTAINED AT THE UNIVERSITY OF TEXAS AT AUSTIN IN CONJUNCTION WITH THE ATS-6 MM WAVE EXPERIMENT ARE PRESENTED. ATTENUATION MEASUREMENTS AT 30 GHZ AND SKY NOISE DATA AT 20 GHZ WERE OBTAINED SIMULTANEOUSLY AT EACH OF TWO SITES SEPARATED BY 11 KM. SPACE DIVERSITY REDUCED OUTAGE TIME FOR A SYSTEM IN AUSTIN, TEXAS WITH A 10 DB FADE MARGIN AT 30 GHZ FROM 15 HOURS TO 15 MINUTES PER YEAR. THE MAXIMUM CLOUD HEIGHT SHOWS A GOOD CORRELATION TO THE MAXIMUM ATTENUATIONS MEASURED.**

511174I*HODGE, D.B.*MILLIMETER WAVELENGTH PROPAGATION STUDIES*FINAL REPORT 2374-18*NGR-36-008-080*NO #*JULY 1974*N74-29495*THIS IS A FINAL SUMMARIZING THE INVESTIGATIONS CONDUCTED UNDER A NASA GRANT (ABOVE) ENTITLED MM WAVELENGTH PROPAGATION STUDIES FOR THE PERIOD DEC 1966 TO JUNE 1974. THESE EFFORTS INCLUDED THE PREPARATION FOR THE ATS-5 MM WAVELENGTH PROPAGATION EXPERIMENT AND THE SUBSEQUENT DATA ACQUISITION AND ANALYSIS. THE EMPHASIS OF THE OSU PARTICIPATION IN THIS EXPERIMENT WAS PLACED ON THE DETERMINATION OF RELIABILITY IMPROVEMENT RESULTING FROM THE USE OF SPACE DIVERSITY ON A MM WAVELENGTH EARTH-SPACE COMMUNICATION LINK; THIS EFFORT REPRESENTED THE FIRST ATTEMPT TO PERFORM SPACE DIVERSITY MEASUREMENTS USING AN ACTUAL EARTH-

SPACE LINK OPERATING ABOVE 10 GHZ. RELATED MEASUREMENTS PERFORMED AS A PART OF THIS EXPERIMENT INCLUDED THE DETERMINATION OF THE CORRELATION BETWEEN RADIOMETRIC TEMPERATURE AND ATTENUATION ALONG THE EARTH-SPACE PROPAGATION PATH.**

622181C*LIEBE, H.J. AND WELSH, W.M.*MOLECULAR ATTENUATION AND PHASE DISPERSION BETWEEN 40 AND 140 GHZ FOR PATH MODELS FROM DIFFERENT ALTITUDES*O.T. REPORT 73-10*NO #*MAY 1973*N74-25886*RADIO WAVE PROPAGATION IN THE 40-140 GHZ BAND THROUGH THE FIRST 100 KM OF THE ATMOSPHERE IS STRONGLY INFLUENCED BY THE UWAVE SPECTRUM OF OXYGEN (O2-MS). A UNIFIED TREATMENT OF MOLECULAR ATTENUATION AND PHASE DISPERSION IS FORMULATED. RESULTS OF MOLECULAR PHYSICS ARE TRANSLATED INTO FREQUENCY, TEMPERATURE, PRESSURE AND MAGNETIC FIELD DEPENDENCIES OF A COMPLEX REFRACTIVE INDEX. THE INTENSITY DISTRIBUTION OF THE O2-MS UNDERGOES SEVERAL CHANGES WITH INCREASING ALTITUDE.**

D121217*MINTZER, D.*MICROWAVE CONDUCTIVITY OF SLIGHTLY IONIZED GASES AND ELECTROMAGNETIC SCINTILLATIONS*NGR-14-007-071*NO #*MAY 1972*N74-21804*THIS IS A FINAL REPORT ON A 2-1/2 YEAR GRANT; TWO LINES OF RESEARCH WERE PURSUED: 1) MICROWAVE CONDUCTIVITY OF SLIGHTLY IONIZED GASES; 2) SCINTILLATION OF RADIO WAVES FROM ASTRONOMICAL SOURCES. REPORTS WRITTEN ON THESE OPTICS ARE LISTED IN THE REFERENCES.**

B21462A*SCHOERER, G.*TERRESTRIAL RADIOMETRY AT 3 MM WAVELENGTH*CH-3000-BERN*BERN UNIVERSITY, SWITZERLAND (IN GERMAN)*JUNE 1976*N76-10606*THIS PAPER DESCRIBES SOME THERMAL MEASUREMENTS MADE OF OBJECTS AT 3 MM WAVELENGTH -- TRACKS, CEM. BUILDINGS, MOTORBOATS WITH PHOTOGRAPHIC COMPARISONS. TITLES IN THE ARTICLE ARE: DESCRIPTION OF THE 3 MM IMAGING RADIOMETER, CALCULATIONS INVOLVING MICROWAVE RADIOMETER, THERMOGRAMS OF NATURAL OBJECTS, DETECTION OF METALS, DETECTION OF PASSENGER CAR, DETECTION OF SHIPS, INVESTIGATION BY SMALL PICTURES, CONCLUSIONS.**

B214618*HOFER, R.*REFLECTION AND EMISSION PROPERTIES OF NATURAL AND ARTIFICIAL MATERIALS AT 3 MM WAVELENGTH*CH-3000-BERN*BERN UNIVERSITY, SWITZERLAND (IN GERMAN)*JUNE 1974*N76-10826*EXPERIMENTAL DATA FOR NINE MATERIALS FOR REFLECTION AND EMISSION VS NADIR ANGLE GIVEN, WITH A MEASURING FREQUENCY OF 94 GHZ. MATERIALS CONSIDERED WERE WATUR, METAL TURNINGS, SAND, DIRT/LOAM, BRICK, GRASS, FIR WOOD, OIL COATED METAL PLATE, AND SNOW.**

513161F*MATTHEWS, R.W.; ROUSE, J.W.; MOLLOWY, M.W.; ET AL.*ACTIVE MICROWAVE WORKSHOP REPORT*NASA-SP-376*NO #*MARCH 27, 1975*N76-11811-11818*THIS IS A SYMPOSIUM PUBLICATION RESULTING FROM AN INVITATION FROM NASA/HOUSTON "OPPORTUNITIES FOR PARTICIPATION IN FUTURE APPLICATIONS PROGRAM,"--THE PURPOSE WAS TO FORM AN ADHOC ACTIVE UWAVE WORKING GROUP WHOSE OBJECTIVE WAS TO REVIEW AND DEFINE THE ANTICIPATED ADVANTAGES OF ACTIVE MICROWAVE SYSTEMS IN FUTURE AEROSPACE APPLICATIONS PROGRAMS. THE GROUP MET FROM JULY 22-26, 1974 AT NASA/HOUSTON. THIS MAY BE CONSIDERED A "REMOTE SENSING BY MICROWAVE SOURCE BOOK" FOR FURTHER USERS. WAVE BANDS INCLUDED ARE 30 CM - 1 MM. N76-11818 - "TECHNICAL BACKGROUND" DESCRIBES THE PHYSICS OF E M SCAT-

TERING FROM THE SEAS. MICROWAVE RADIOMETRY EQUATIONS ARE DEVELOPED.**

C11731A*WEBST, J., WM. J.*ON THE DETERMINATION OF ATMOSPHERIC PATH LENGTH BY A PASSIVE MICROWAVE RADIOMETER*NO #*NO #*MAY 1975*N75-33568 (NASA TM X-70967)*THIS ARTICLE DESCRIBES THE USE OF A MICROWAVE RADIOMETER SYSTEM (18-53 GHZ) TO DETERMINE THE ATMOSPHERIC WATER CONTENT WHICH THEY SAY, CAN CHANGE SIGNIFICANTLY IN 20 MINUTES IN A CERTAIN ITEM. THIS ATMOSPHERIC WATER CONTENT VARIABILITY IS THE CHIEF CAUSE FOR ERRORS IN GEODETIC MEASUREMENTS MADE VIA VISIBLE LIGHT MEANS. ERRORS AS MUCH AS 2 CM CAN BE MADE DUE TO THIS VISIBILITY.**

121121P*HARRIES, J.E. AND BURROUGHS, W.J.*OBSERVATIONS OF MM WAVELENGTH SOLAR RADIATION AT SEA LEVEL*NO #*INFRARED PHYSICS, VOL. 10, 165-172*1970*NO #*THIS PAPER REPORTS THE RESULT OF GROUND LEVEL MEASUREMENTS OF THE ABSORPTION OF SOLAR RADIATION AT MILLIMETER WAVELENGTHS BY THE EARTH'S ATMOSPHERE. USING A MICHELSON INTERFEROMETER WITH A ROLLIN DETECTOR, HIGH QUALITY SPECTRA HAVE BEEN OBTAINED OVER THE RANGE 2-12 CM-1. ABSORPTION FEATURES DUE TO H2O AND O2 HAVE BEEN OBSERVED, AND OF PARTICULAR INTEREST IS THE O2 TRANSITION J=0 TO J=1 FOR K=1 LINE AT 4X0 CM-1, WHICH HAS NOT BEEN PREVIOUSLY OBSERVED USING BROAD-BAND TECHNIQUES. WEAK ABSORPTION FEATURES HAVE BEEN RECORDED IN THE 8 CM-1 WINDOW, AND THESE HAVE BEEN ASSIGNED TO THE DIMER OF WATER VAPOR (H2O)2. THE SPECTRA OBTAINED AT SEA-LEVEL HAVE BEEN COMPARED WITH OTHERS OBTAINED AT AN ALTITUDE OF 3580 M, AND FROM THIS COMPARISON IT HAS BEEN DEDUCED THAT THE LACK OF OBSERVATION OF A DISCRETE ABSORPTION FEATURE IN THE 7-9 CM-1 REGION BY EARLIER WORKERS IS DUE LARGELY, AT SEA LEVEL, TO THE EFFECT OF THE RELATIVELY HIGH PRESSURE AND TEMPERATURE EXISTING AT THE EARTH'S SURFACE. THE FEASIBILITY OF USING THE PRESENT TECHNIQUES IN ORDER TO MEASURE METEOROLOGICAL PARAMETERS SUCH AS HUMIDITY AND TEMPERATURE IS DISCUSSED.**

C23151E*CHANTRY, G.W.; EVANS, HELEN M.; CHAMBERLAIN, JOHN; AND GEBBIE, H.A.*ABSORPTION AND DISPERSION STUDIES IN THE RANGE 10-1 - 1000 CM-1 USING A MODEULAR MICHELSON INTERFEROMETER*NO #*INFRARED PHYSICS, VOL. 9, 85-93*1969*NO #*A MODULAR MICHELSON INTERFEROMETER HAS BEEN DEVELOPED FOR USE AS A FOURIER TRANSFORM SPECTROMETER PROVIDING BOTH ABSORPTION AND REFRACTION SPECTRA. THE SPECTRAL RANGE THAT IT WAS INTENDED TO COVER, 10-200 CM-1, REPRESENTS ONLY A PART OF ITS USEFUL RANGE WHICH EXTENDS TO 500 CM-1. IT IS SHOWN THAT A FEW SIMPLE MODIFICATIONS ENABLE THE UPPER FREQUENCY LIMIT TO BE RAISED TO 1000 CM-1. THERE IS NO EVIDENCE FOR FREQUENCY ERRORS GREATER THAN THE RESOLUTIOH LIMIT, NOR ARE THERE ANY SPURIOUS FEATURES PRESENT IN THE SPECTRA DUE TO ARTEFACTS.**

C33151F*CHAMBERLIN, JOHN; GIBBS, J.E.; AND GEBBIE, H.A.*THE DETERMINATION OF REFRACTIVE INDEX SPECTRA BY FOURIER SPECTROMETRY*NO #*INFRARED PHYSICS, VOL. 9, 185-209, 1969*NO #*IF A DISPERSIVE MEDIUM ISINTRODUCED INTO ONE ARM OF A MICHELSON INTERFEROMETER IRRADIATED BY A WIDE BAND OF

RADIATION, THE TWO-BEAM INTERFEROGRAM CONTAINS DETAILED INFORMATION ABOUT THE VARIATION OF THE COMPLEX REFRACTIVE INDEX OF THE MEDIUM WITH WAVE-NUMBER. RECENT EXPERIMENTAL WORK IN THE INFRA-RED SPECTRAL REGION HAS SHOWN THAT THIS INFORMATION MAY BE RECOVERED TO GIVE THE COMPLEX REFRACTION SPECTRUM OF THE MATERIAL. DETAILS OF THE MATHEMATICAL THEORY AND THE NECESSARY OBSERVATIONS AND COMPUTATIONS ARE GIVEN, AND ILLUSTRATED BY THE RESULTS OF RECENT IN-VESTIGATIONS OF THE REFRACTION SPECTRA OF SPECIMENS IN EACH OF THE THREE MATERIAL PHASES.**

5511A1G*BIRCH, J.R.; BURROUGHS, W.J.; AND EMERGY, R.J.* OBSERVATION OF ATMOSPHERIC ABSORPTION USING SUB MM MASER SOURCES*NO #*INFRARED PHYSICS, VOL. 9, 75-83*1969*NO #* USING FIVE SUBMILLIMETER MASER EMISSION LINES THE ABSORP-TION OF THE ATMOSPHERE AND OF PURE WATER VAPOR HAVE BEEN EXPERIMENTALLY DETERMINED; THE LATTER AS A FUNCTION OF PRESSURE. THESE RESULTS HAVE BEEN COMPARED WITH VALUES DERIVED FROM A COMPLETE THEORETICAL ANALYSIS BASED ON MONOMERIC WATER VAPOR ONLY. THIS COMPARISON LEADS TO CONCLUSIONS THAT ATMOSPHERIC ABSORPTION IN THE SPECTRAL REGION 32 - 100 CM-1 MAY BE EFFECTIVELY COMPUTED USING A THEORETICAL MODEL WHICH CONIDERS MONOMERIC WATER VAPOR ALONE; AND THAT FOR ABSORPTION BY PURE WATER VAPOR A SMALL DEVIATION EXISTS WHICH IS CONSISTENT WITH THE THEORETICALLY EVALUATED SPECTRUM OF THE WATER VAPOR DIMER.**

531581C*HARRIES, J.E. AND ADE, P.A.R.*ABSORPTION BY MINOR ATMOSPHERIC CONSTITUTENTS NEAR 8 CM-1*NO #*INFRARED PHYSICS, VOL. 12, 143-144*1972*NO #*IN THE PREVIOUS ISSUE OF INFRARED PHYSICS, A.G. KISLYAKOV (VOL. 12, P61-63, 1972) OFFERED SOME CRITICISM OF OUR EARLIER WORK, IN THAT INSUFFICIENT CONSIDERATION WAS GIVEN TO ABSORPTION BY OTHER MINOR ATMOSPHERIC GASES WHEN CONSIDERING THE 8 CM-1 WINDOW REGION. DUE CONSIDERATION HAS, IN FACT, ALWAYS BEEN GIVEN BY US TO THESE ABSORBERS AND THE CRITI-CISMS HAVE LARGELY BEEN MET IN THE PAPER ON PAGE 81 OF THIS ISSUE, BUT WE WOULD LIKE TO DESCRIBE MORE EXPLICITLY THE ARGUMENTS MENTIONED RATHER BRIEFLY IN THE PAPER.**

133141M*EMERY, R.*ATMOSPHERIC ABSORPTION MEASUREMENTS IN THE REGION OF 1 MM WAVELENGTH*NO #*INFRARED PHYSICS, VOL. 12, 65-79*1972*NO #*USING A FROOME-TYPE PLASMA-METAL JUNCTION HARMONIC GENERATOR· HIGH RESOLUTION TRANSMISSION MEASUREMENTS HAVE BEEN MADE ON THE ATMOSPHERE IN THE WAVE-LENGTH RANGE 0.5-3.0 MM. THEORETICAL SPECTRA HAVE BEEN COMPUTED FOR SUBMILLIMETER-MILLIMETER WAVELENGTH ATMO-SPHERIC ABSORPTION DUE TO WATER VAPOR USING THEK KINETIC EQUATION FORM FOR THE LINE SHAPE. MEASUREMENTS WERE MADE ON THE BASIC PARAMETERS OF THE MAIN WATER VAPOR ABSORP-TION LINES OCCURRING IN THE WAVELENGTH RANGE 0.65-3.0 MM. THE PURE WATER VAPOR LINE WIDTH PARAMETERS ARE FOUND TO BE CONSTANT FOR THE THREE MAIN ABSORPTION LINES IN THIS RANGE AND EQUAL TO 0.55 + OR - 0.05 CM-1. THE WATER VAPOR-NITRO-GEN LINE WIDTH PARAMETER FOR THE 1.64 MM WAVELENGTH LINE IS MEASURED TO BE 16 PERCENT LARGER THAN THEORY HAVING A VALUE OF 0.111 + OR - 0.005 CM-1 AND IS CONSTANT OVER A

RANGE OF PRESSURES. COMPARISON BETWEEN THEORY AND OBSERVATION FOR THE ABSORPTION IN TWO SUBMILLIMETER WAVELENGTH WINDOWS STRONGLY FAVORS THE KINETIC EQUATION FORM OF THE LINE SHAPE RATHER THAN THEMORE USUAL LORENTZ SHAPE.**

5321817*KISLYAKOV, A.S.*ON THE ATMOSPHERIC TRANSPARENCY SPECTRUM IN THE (8 CM-1) MM BAND*NO #*INFRARED PHYSICS, VOL. 12, 61-63*1972*NO #*THE RECENT EXPERIMENTAL DATA IN PAPERS BY GEBBIE AND BURROUGHS ON THE MILLIMETER ATMOSPHERIC TRANSPARENCY SPECTRA ARE DISCUSSED. THE MAIN ATTENTION IS PAID TO THE QUESTION WHETHER SMALL ATMOSPHERIC CONSTITUENTS OCCUR IN THESE SPECTRA OR NOT.**

532141G*HARIES, J.E. AND ADE, P.A.R.*THE HIGH RESOLUTION MM WAVELENGTH SPECTRUM OF THE ATMOSPHERE*NO #*INFRARED PHYSICS, VOL 12, 81-94*1972*NO #*THIS PAPER PRESENTS NEW MEASUREMENTS WHICH WE HAVE MADE OF THE SPECTRUM OF SOLAR RADIATION ATTENUATED BY THE EARTH'S ATMOSPHERE, OBSERVED FROM SEA LEVEL WITH THE 1.5 M DIAMETER TELESCOPE AT QUEEN MARY COLLEGE. THE EXPERIMENTAL SYSTEM CONSISTS OF A PHASE-MODULATED MICHELSON INTERFEROMETERAND A ROLLIN DETECTOR, AND WITH IT SPECTRA HAVE BEEN OBTAINED TO A RESOLUTION OF 0.125 CM-1, WITH VERY HIGH SIGNAL-TO-NOISE RATIOS. AS WELL AS CLEAR OBSERVATION OF THE WELL-KNOWN H2O AND O2 LINES, A NUMBER OF WEAK FEATURES ARE DETECTED, SOME FOR THE FIRST TIME. THE NATURE OF THESE WEAK LINES, PARTICULARLY THOSE AT 7.7 CN-1 AND 8.8 CM-1 IS DISCUSSED, THE MOST FAVORABLE ASSIGMENT FOR THE LATTER STILL BEING TO THE WATER DIMER MOLECULAR (H2O)2.**

5211818*WHITE, W.F.*MICROWAVE SPECTRAL LINE LISTING*NASA-TN D-8053*NO #*NOV 1975*N76-11841*THE FREQUENCY, INTENSITY AND IDENTIFICATION OF 9615 SPECTRAL LINES BELONGING TO 75 MOLECULES ARE TABULATED IN ORDER OF INCREASING FREQUENCY. MEASUREMENTS FOR ALL 75 MOLECULES WERE MADE IN THE FREQUENCY REGION OF 26.5 TO 40 GHZ BY A COMPUTER CONTROLLED SPECTROMETER. MEASUREMENTS WERE ALSO MADE FOR 18 GHZ TO 26.5 GHZ FOR SOME MOLECULES.**

522731E*MALOTA, F. AND SKIN, VOLKER*GROUND-BASED MULTI-SPECTRAL PASSIVE MICROWAVE SOUNDING OF AN ATMOSPHERIC TEMPERATURE PROFILES NEAR 60 GHZ*NO #*DLR-FB-76-01* DEC 1975*N76-22840*THIS IS A THEORETICAL STUDY OF THE MEASUREMENT OF ATMOSPHERIC TEMPERATURE FOR A GROUND BASED 60 GHZ RADIOMETER. THE RELATION BETWEEN ATMOSPHERIC PARAMETERS AND THERMAL MICROWAVE RADIATION IS DERIVED. THE INFLUENCE OF VARIOUS ATMOSPHERIC CONDITIONS (COLD, MIDDLE ALTITUDE, HOT ATMOSPHERE), CLOUD FORMATIONS AS WELL AS TEMPERATURE INVERSION LAYERS NEAR EARTH SURFACE UPON THE NOISE TEMPERATURES IS INVESTIGATED. SOME COMPUTATIONAL RESULTS ARE PRESENTED FOR THE RECONSTRUCTION PROBLEMS OF VERTICAL TEMPERATURE PROFILES FROM MEASURED VALUES OF THE NOISE TEMPERATURE.**

52267A*BERMAN, ALLEN L. AND ROCKWELL, STEPHEN T.*NEW OPTICAL AND RADIO FREQUENCY ANGULAR TROPOSPHERIC REFRACTION MODELS FOR DEEP SPACE APPLICATIONS*NO #*NASA-CR-148534*NOV 1973* N76-28449*THIS PAPER PRESENTS THE DEVELOPMENT OF ANGULAR TROPHOSPHERIC REFRACTION MODELS FOR OPTICAL AND RADIO FREQUENCY USAGE. THE MODELS ARE COMPACT ANALYTIC FUNCTIONS

FINITE OVER THE ENTIRE DOMAIN OF ELEVATION ANGLE, AND ACCURATE OVER LAREGE RANGES OF PRESSURE, TEMPERATURE, AND RELATIVE HUMIDITY. ALSO, FORTRAN SUBROUTINES OF EACH OF THE MODELS ARE INCLUDED.**

2315818*BLUE, M.D.*PERMITTIVITY OF WATER AT MM WAVELENGTH*NO #* GEORGIA TECH/NASA GRANT NSG-5082*AUG 1976*N76-30911*THIS REPORT DESCRIBES THE MM WAVE REFLECTIVITY MEASUREMENTS OFF OF WATER, ICE AND SIMULATED SEA WATER (WITH PLANKTON CONTENT) AT 100 GHZ. FROM THESE MEASUREMENTS, USING MERCURY AS A PERFECT REFLECTOR, THE COMPLEX DIALECTRIC CONSTANTS WERE DERIVED FOR THESE MATERIALS. THE RESULTS AGREE WELL WITH THE WORK OF PETER RAY (APPL.OPTICS, VII, 1836 (1972)).**

A631838*HARRIS, F.S., ET AL.*ATMOSPHERIC AEROSOLS: THEIR OPTICAL PROPERTIES AND EFFECTS*NO #*NASA-CR-2004*DEC 1975* N77-15563*THIS IS A COLLECTION OF PAPERS ON ATMOSPHERIC AEROSOLS AND THEIR OPTICAL PROPERTIES GIVEN AT A SYMPOSIUM AT NASA LANGLEY RESEARCH CENTER, SPONSORED BY NASA AND THE OPTICAL SOCIETY OF AMERICA. THIS HAS LITTLE TO DO WITH MICROWAVES, BUT MUST BE CONSIDERED AN IMPORTANT SOURCE COLLATION ON AEROSOL PHYSICAL PROPERTIES.**

A631828*HARRIS, F.S., ET AL., EDITOR*ATMOSPHERIC AEROSOLS: THEIR OPTICAL PROPERTIES AND EFFECTS (SUPPLEMENT)*NO #* NASA-CR-2004 SUPPLEMENT*1976*N77-15664*THIS IS A CONTINUATION OF N77-15663 OF THE SAME TITLE ON THE CONFERENCE PROCEEDINGS OF A NASA/OPTICAL SOCIETY OF AMERICA CONFERENCE AT NASA LANGLEY, DEC 13-15, 1975. THIS WITH THE PREVIOUS PAPER IS A STANDARD REFERENCE ON AEROSOL PROPERTIES THOUGH IT HAS LITTLE INFOR ON MM PROPERTIES.**

511171C*FONG, D.J. AND HARRIS, J.M.*PRECIPITATION-ATTENUATION STUDIES BASED ON MEASUREMENTS OF ATS-6 20/30 GHZ BEACON SIGNAL AT CLARKSBERG, MD*NO #*COMSAT LABS, NASA-CR-152501* JULY 1, 1976*N77-23295*THIS PAPER DISCUSSES EXPERIMENTS MEASURING THE 20 AND 30 GHZ ATMOSPHERES AS A FUNCTION OF TIME USING ATS-6'S BEACONS AS A CALIBRATED SOURCE. THE ATTENUATION VS TIME WAS CORRELATED WITH SKY RADIOMETRIC NOISE AT THESE SAME FREQUENCIES; THE MATCVH WAS MODERATELY GOOD. RAIN GAUGES WERE POSITIONED UNDER THE PATH OF MM BEAM TO THE ALTITUDES TO RECORD THE RAINFALL RATE AND THEN CORRELATE WITH THE ATTENUATION VS TIME MEASURED BY THE GROUND STATIONS. THE CORRELATIONS MAY BE USED FOR INDIRECTLY ESTIMATING LONG TERM CUMULATIVE ATTENUATION STATISTICS IN THE ABSENCE OF DIRECT SATELLITE SIGNAL MEASUREMENTS.**

C215417*BERTOLINE, F; COTTANI, G. AND ROGAI, S*COMPLEX DIELECTRON CONSTANT MEASUREMENTS IN THE FIELD OF MM WAVES (IN ITALIAN)*NO #*FONDAZIONE UGO BARDONI*MAY 24 1976*N77-25376* THE COMPLEX DIELECTRIC CONSTANT OF A PLASTIC BICC WAS MEASURED FROM 40-50 GHZ IN A CIRCULAR CAVITY REFLECOMETER USING A BWV AS A POWER SOURCE. THE REASON FOR THIS WORK WAS TO PROVIDE A BASIS FOR DESIGN OF HIGHER (THAN 30 GHZ) FREQUENCY DIELECTRIC IN CAVITY MEASUREMENT HARDWARE.**

C13181D*THOMAS,J., M.C.; OTT, R.H.; AND VIOLETTE, E.J.* REPORT ON 1976 MM WAVE CONFERENCE*NO #*OFFICE OF TELECOMMUNICATIONS, U.S. DEPARTMENT OF COMMERCE, DENVER*SEPT 1976*PB-258 576*TITLE AND SPEAKERS ONLY WERE GIVEN; USES OF

RADIO SPECTRUM ABOVE 10 GHZ WAS EMPHASIZED. TITLE AND SPEAKERS ARE: 1) "A NEW APPROACH TO MM WAVES," N.E. FELDMAN, ET AL., RAND. 2)"MILITARY PLANS FOR MM WAVES," DR. P. JAIN, D.C.A. 3) "SOME ASPECTS OF MM WAVE RESEARCH OF B.T.L.," DR. L. TILLETSON, B.T.L. 4) "THE ROLE OF THE F.C.C.," A. REINER, F.C.C. 5) "SURVEY OF SOLID STATE MM WAVE SOURCES," DR. B. FORK, VARIAN 6) "COMMUNICATION SATELLITES," DR. L. IPPOLITE, NASA 7)"MM WAVE PROPAGATION ON TERRESTRIAL AND EARTH SPACE PATHS," DR. D. HAYS, B.T.L. 8) "ELECTROMAGNETIC," DR. H. BOYNE, N.B.S.**

521131C*REBER, E.E*ABSORPTION OF THE 4-6 MM WAVELENGTH BAND IN THE ATMOSPHERE*NO #*AEROSPACE CORP., SAMSO-TR-72-151* MAR 15 1972*AD-745-951*THIS REPORTS ON THE MEASUREMENTS OF ATMOSPHERIC ATTENUATION OF SIGNALS FROM 48-72 GHZ RECEIVED BY A ZENITH POINTING RADIOMETER - THE SUN AS A MM SOURCE. WITH MEASUREMENTS OF THE PRECIPITABLE WATER CONTENT IN THE ATMOSPHERE. THE ATTENUATION DUE TO O2 WAS DETERMINED. THE ZENITH O2 ATTENUATIONS AS A FUNCTION OF FREQUENCY AND ALTITUDE WERE USED TO COMPARE THE THEORIES FOR COLLISION BROADENED SPECTRAL LINES, AND TO DEVELOP A NEW EXPRESSION FOR PRESSURE PRODUCED SPECTRAL LINES. THIS REPORT HAS A GOOD BIBLIOGRAPHY ON MEASUREMENTS IN THE 60 GHZ O2 LINE.**

942161C*KIRSCHNER, S.M.; LEROY, R.J.; OGILVIE, J.F.; AND TIPPING, R.H.*RADIAL MATRIX ELEMENTS AND DIPOLE MOMENT FUNCTION FOR THE GROUND STATE OF CO'*NO #*JOURNAL OF MOLE-CULAR SPECTROSCOPY 65, 306-312*1977*NO #*RADIAL MATRIX ELEMENTS X SUPER(K) FOR K=0 TO K=5, V=0 TO V=12, ABSO-LUTE V1-V)=0 TO 4, AND J UP TO 150 HAVE BEEN CALCULATED FOR 12C16O USING ACCURATE WAVE FUNCTIONS OBTAINED FROM THE NUMERICAL SOLUTION OF THE SCHROEDINGS EQUATION WITH A SECOND ORDER RKR POTENTIAL CURVE. THESE SHOULD BE USEFUL IN CALCULATING EMISSION AND ABSORPTION PROPERTIES OF CARBON MONOXIDE IN THE IR AND SUB MM RANGE.**

C41151C*BATT, R.J. AND HARRIS, D.J.*AN OPEN RESONATOR TECH-NIQUE FOR THE MEASUREMENT OF ATMOSPHERIC PROPAGATION CHARACTERISTICS AT SUBMILLIMETER WAVELENGTHS*NO #*INFRARED PHYSICS, VOL. 16, 325-327*1976*NO #*A 3-MIRROR OPEN RESONA-TOR TECHNIQUE OPERATING IN THE MILLIMETER BAND IS DESCRIBED. THIS TECHNIQUE IS USED WITH A 337 UM LASER TO MEASURE THE ABSORPTION OF AIR WITH VARYING WATER VAPOR CONTENT. THE "Q" OF THE RESONATOR STRUCTURE IS LOWERED WITH THE ADDITION OF WATER VAPOR, RELATIVE TO THE "Q" WITH DRY AIR, WITH THE INVERSE OF THE LOADED CAVITY Q LINEARLY VARYING WITH THE RELATIVE HUMIDITY, OR, THE ABSOLUTE AMOUNT OF WATER VAPOR/UNIT VOLUME, IN GM CM-3.**

731151E*GEBBIE, H.A.; STONE, N.W.B.; TOPPING, G.; GORA, E.K.; CLORICH, S.A.; AND KNEIZYS, F.X.*ROTATIONAL ABSORPTION OF SOME ASYMMETRIC ROTOR MOLECULES. PART I. OZONE AND SULFUR DIOXIDE*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 19, 7-24*1966*NO #*FOR 112 SPECTRUM OF OZONE AND SULFUR DIOXIDE HAVE BEEN OBTAINED INTERFEROMETRICALLY WITH A RESOLUTION OF 0.25 AND .12 CM-1, RESPECTIVELY. IN THE CASE OF OZONE, AGREEMENT WITH PREDICTIONS BASED ON PREVISOULY PUBLISHED MICROWAVE DATA HAS BEEN CONFIRMED. FOR SO2, THE FAR IR INDICATED THE NEED OF TAKING HIGHER ORDER ANTRIFUGAL

DISTORTION CORRECTIONS INTO CONSIDERATION. A NON-LINEAR CORRECTION, CALLED K6, IS CALCULATED FOR O3 AND SO2 AND IS ALSO GIVEN FOR H2O, NO2, ALSO, AND ARE COMPARED WITH THOSE CALCULATED FOR O3 AND SO2.**

C51731A*FAZIO, G.G.*A 102 CM BALLOON-BORNE TELESCOPE FOR FAR IR ASTRONOMY*NO #*HARVARD COLLEGE OBSERVATORY, OPTICAL ENGINEERING, VOL. 16, NO. 6, 551-557*NOV-DEC 1977*NO #*THIS ARTICLE PRESENTS THE INSTRUMENTATION CHARACTERISTICS AND SOME EXPERIMENTAL RESULTS ION THIS BALLOON-BORNE FAR IR TELESCOPE. IT'S PURPOSE IS TO PERFORM RADIOMETRY AND FAR IR (40 UM-250 UM) MAPPING OF CELESTIAL SOURCES. SIX FLIGHTS HAVE PRODUCED MUCH ASTRONOMICAL DATA, WITH 40 HOURS OF OBSERVATIONS OF HII REGIONS, DARK CLOUDS, MOLECULAR CLOUDS GALAXIES, ETC.**

713181B*TANAHA, TCHEHIKO AND MORINO, YONZO*CORIOLIS INTERACTION AND ANHARMONIC POTENTIAL FUNCTION OF OZONE FROM THE MICRO-WAVE SPECTRA IN THE EXCITED VIBRATIONAL STATES*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 33, 538-551*1970*NO #*MICROWAVE ABSORPTION SPECTRA (8-70 GHZ) WERE IDENTI-FIED IN THE EXCITED VIBRATIONAL STATE WITH V1=1, V2=1, AND V3=1 STATES. THE INERTIA DEFECT IN THE CORIOLI PERTURBED STATE WAS DEFINED AND SUCCESSFULLY APPLIED TO THE ANALYSES. CUBIC AND QUANTITATIVE POTENTIAL CONSTANTS WERE DEFINED AND EVALUATED. CLOSE SIMILARITIES WERE OBSERVED AMONG THE ANHARMONIC POTENTIAL CONSTANTS OF O3, SO2, AND OF2.**

743182C*BARBE, A.; SECROUN, C.; JOURIE, P.; MONNANTEUIL, N.; DEPANNEMAECHER, B.DUTERAGE; AND BELLET, J.*INFRARED AND MICROWAVE HIGH-RESOLUTION SPECTRUM OF THE V3 BAND OF OZONE*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 64, 343-364*1977*NO #*THE VIBRATION-ROTATION BAND OF V3 OF OZONE HAS BEEN RECORDED WITH A HIGH RESOLUTION (.012 CM-1) SPECTROMETER, AND MICROWAVE ABSORPTION SPECTRA OF OZONE HAS BEEN IDENTIFIED IN THE EXCITED VIBRATIONAL STATES (100) AND (001). A STRONG CORIOLIS INTERACTION HAS BEEN OBSERVED. MORE THAN 1200 SPECTRAL LINES HAVE BEEN IDENTIFIED IN THE V3 BAND. IT IS SHOWN THAT TRANSITIONS WITH HIGH VOLUMES OF THE QUANTUM NUMBERS K-1 (7,11) CONTRIBUTE TO SIGNIFICANT DISTORTION.**

7431819*LICHTENSTEIN, M. AND GALLAGHER, J.J.*MILLIMETER WAVE SPECTRUM OF OZONE*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 40, 10-26*1971*NO #*THE MICROWAVE SPECTRUM OF O3 HAS BEEN OBSERVED TO THE FREQUENCY OF 320 GHZ, AND THE SPECTRUM RE-CALCULATED TO OBTAIN NEW ROTATIONAL CONSTANTS FOR THE MOLECULE. THE STARK EFFECT HAS BEEN MEASURED TO YIELD RMS VALUE OF THE DIPOLE MOMENT OF 0.5324 PLUS OR MINUS .0024 DEBYE. ROTATIONAL CONSTANTS FOR THE VIBRATIONAL GROUND STATE OF O3 ARE GIVEN.**

213171G*BOSTIAN, C.W.; STUTZMAN, W.L.; WILEY, P.H.; AND MARSHALL, R.E.*THE INFLUENCE OF POLARIZATION ON MILLIMETER WAVE PROPAGATION THROUGH RAIN*NGR-47-004-091*NO #*JAN 1974*N75-27212*THIS REPORT PRESENTS THE ESSENTIAL FINDINGS OF A 27 MONTH EXPERIMENTAL AND THE ACTUAL INVESTIGATION INTO THE INFLUENCE OF POLARIZATION ON MM WAVE PROPAGATION THROUGH RAIN. THE INVESTIGATION WAS SUPPORTED BY NASA TO EXPLORE A) THE LIMITATIONS WHICH PRECIPITATION DEPOLARIZATION WITH WITH PLACE ON FUTURE MM WAVE EARTH - SATELLITE COMMUNICATION

SYSTEMS EMPLOYING ORTHOGONAL POLARIZATION FREQUENCY SHARING AND B) THE POSSIBILITY OF IMPROVING THE FADE RESISTANCE OF SUCH SYSTEMS, EITHER THROUGH POLARIZATION DIVERSITY OPERATION OR BY THE CHOICE OF POLARIZATION(S) BLAST SUBJECT TO ATTENUATION. TO FACILITATE THE EXPERIMENTAL WORK, THE EFFORTS DESCRIBED IN THIS REPORT WERE CONFINED LARGELY TO GROUND BASED COMMUNICATIONS SYSTEM.**

513161E*FARROW, J.B.*THE INFLUENCE OF THE ATMOSPHERE ON REMOTE SENSING MEASUREMENTS, VOL. I*CONTRACT NO. ESRO 1837/72PP AND 1838/72PD*NO #*DEC 1973*N74-20986*THIS IS A SUMMARY REPORT OVER TWO STUDIES: INFLUENCE OF THE ATMOSPHERE ON REMOTE SENSING AT 1) WAVELENGTHS FROM UV TO INFRA RED (.3 UM TO 15 UM) AND 2) UWAVE AND RADIO WAVELENGTH (1 MM-30 CM). INFORMATION IS PROVIDED ON THE BASIC PURPOSE OF ATMOSPHERIC PROCESSES WHICH INFLUENCE REMOTE SENSING MEASUREMENTS. TYPES OF PROCESSIVE DESCRIBED AND DISCUSSED, AND THE INFLUENCE OF THE ATMOSPHERE ON INCIDENT AND REFLECTED SOLAR RADIATION AND ON EMITTED SCENE RADIATION ARE THEN DESCRIBED WITH PARTICULAR REFERENCE TO THE MAJOR TYPE OF SENSOR. FINALLY, VARIOUS POSSIBLE MEANS OF CORRECTING ATMOSPHERICALLY DEGRADED DATA ARE REVIEWED.**

B12588G*MASON, P.R.; HASTED, J.B.; AND MOORE, L.*THE USE OF STATISTICAL THEORY IN FITTING EQUATIONS TO DIELECTRIC DISPERSION DATA*NO #*ADVAN. MOL. RELAXATION PROCESS, VOL. 6, 217-232*1976*NO #*THIS PAPER SHOWS HOW A CHOICE MAY BE MADE ON THE BASIS OF STATISTICAL THEORY BETWEEN ALTERNATIVE DIELECTRIC DISPERSION EQUATIONS HYPOTHESISED TO FIT SETS OF EXPERIMENTAL DATA. IT ALSO SHOWS HOW TO FIND THE BEST VALUES AND PROBABLE RANGES OF THE PARAMETERS IN THE EQUATIONS. IT IS FOUND THAT THE IMPROVEMENT IN THE FIT OF THE COLE-COLE EQUATION OVER THE DEBYE THROUGHOUT THE COMPLETE TEMPERATURE RANGE FROM 0 TO 75 DEG C MAKES IT A NEAR STATISTICAL CERTAINTY THAT THERE IS SOME SPREAD OF RELAXATION FORCES IN WATER OVER ALL THIS TEMPERATURE RANGE. A 20 DEG C FOR EXAMPLE, THE PROBABILITY OF THE IMPROVEMENT IN FACT NOT BEING DUE TO CHANGE IS GREATER THAN 92.5%, WHICH THE 90 % CONFIDENCE INTERVAL FOR H, THE COLE-COLE SPREAD PARAMETER IS .0008 LESS THAN H LESS THAN .018.**

522684D*LIN, JAMES C. AND ISHIMARU, AKTRA*MULTIPLE SCATTERING EFFECTS ON WAVE PROPAGATION IN ISOTROPIC SCATTERING MEDIA*CONTRACT NO. F19(628)-69-6-0123*NO #*MARCH 1971*AD-735 284*THE MULTIPLE SCATTERING EFFECTS OF A WAVE PROPAGATION IN AN ISOTROPICALLY SCATTERING RANDOM DISTRIBUTION OF DISCRETE SCATTERERS IS CONSIDERED. THE INTEGRAL EQUATIONS FOR THE COHERENT FIELD AND AVERAGE INTENSITY ARE SOLVED USING FOURIER TRANSFORM TECHNIQUES. AN "INFLUENCE FUNCTION" IS OBTAINED FOR THE AVERAGE INTENSITY, WHICH CAN BE USED AS THE GREEN'S FUNCTION FOR THE SOLUTION OF AVERAGE INTENSITY OF ANY GIVEN SOURCE RADIATION. EXPLICIT EXPRESSIONS ARE GIVEN FOR PLANE, SPHERICAL, AND BEAM WAVES SHOWING THE DEPENDENCE ON VARIOUS WAVE AND MEDIUM PARAMETERS.**

132131D*MCMILLEN, R.W.; GALLAGHER, J.J.; AND COOK, JR., O.M.*CALCULATIONS OF ANTENNA TEMPERATURE, HORIZONTAL PATH ATTENUATION, AND ZENITH ATTENUATION DUE TO WATER VAPOR IN THE FREQUENCY BAND 150-700 GHZ*NO #*IEEE TRANSACTIONS ON MICRO-

WAVE THEORY AND TECHNIQUES, VOL. MTT-25, NO. 6, 484-488* JUNE 1977*NO #*THE RESULTS OF CALCULATION OF ANTENNAE TEMPERATURE AT ZENITH, BOTH WITH AND WITHOUT THE SUN VIEWED AS A SOURCE, ARE GIVEN HORIZONTAL PATH AND TOTAL ZENITH PATH LENGTH ATTENUATION ARE ALSO CALCULATED. EACH OF THESE CALCULATIONS WAS MADE OVER THE FREQUENCY BAND 150-700 GHZ, USING DATA FROM THE 24-WATER ABSORPTION LINES BETWEEN 150 AND 7000 GHZ. A LORENTZIAN LINE SHAPE FACTOR F(V) WAS USED, WITH THE BARRETT AND CHUNG LINE WIDTH PARAMETER.**

142181B*VIKTOROVE, A.A. AND ZHEVEKIN, S.A.*BAND SPECTRUM OF A DIMER OF WATER VAPOR*NO #*SOVIET PHYSICS-DOKLADY, VOL. 15, NO. 9, 836-839*MARCH 1971*NO #*THE BAND SPECTRUM OF A DIMER IN THIS ARTICLE IS TAKEN TO MEAN THE SPECTRUM OF A LINEAR MODEL OF 2 STABLE H2O MOLECULES RIGIDLY BOUND TOGETHER BY A HYDROGEN BAND. A COSINUSOIDAL APPROXIMATION FOR THE POTENTIAL BARRIER FOR INTERNAL ROTATION WAS USED. EFFECTS OF THE H2O-H2O DIMER ARE SEEN IN ITS GREATEST EXTENT IN THE FREQUENCY REGION LAMBDA-1 LT 7 CM-1. THE DIMER ABSORPTION COEFFICIENT IS GIVEN AS FUNCTION OF TEMPERATURE, WAVELENGTH, DIPOLE MOMENT AND ENERGY LEVELS.**

812181E*SPIRKO, V.; STONE, J.M.R.; AND PAPOUSEK, D.*VIBRATION-INVERSION-ROTATION SPECTRA OF AMMONIA: CENTRIFUGAL DISTORTION, CORIOLIS INTERACTIONS AND FORCE FIELD IN 14NH3, 15NH3, 14ND3, AND 14NT3*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 60, 159-178*1976*NO #*AN EFFECTIVE INVERSION-ROTATION HAMILTORIAN HAS BEEN DEVELOPED FOR N3 WHICH AVOIDS THE NECESSITY OF HAVING TO INCLUDE HIGH POWERS OF THE INVERSION MOTION COORDINATE IN THE TAYLOR EXPANSIONS OF THE POTENTIAL ENERGY AND THE INVERSE MOMENT OF INERTIA TENSOR. A LEAST SQUARES PROCEDURE THAT INCLUDES THE NUMERICAL INTEGRATION OF THE SCHROEDINGER WAVE EQUATION HAS BEEN USED TO DETERMINE THE HARMONIC FORCE FIELD AND THE DOUBLE MINIMUM INVERSION POTENTIAL FUNCTION FOR 14NH3, (15)NH3, AND FOR (14)ND3 AND (14)NT3.**

811111D*CURRIES, N.C.; MARTIN, E.E.; AND DYER, F.B.*RADAR FOLIAGE PENETRATION MEASUREMENTS AT MILLIMETER WAVELENGTH* NO #*NO#*DEC 1975*AD-A023 838*A SERIES OF RADAR MEASUREMENTS ON THE PENETRATION OF FOLIAGE HAVE BEEN MADE AT 9.4, 16.2, 35, AND 95 GHZ. MEASUREMENTS WERE MADE FOR BOTH THE 1-WAY AND 2-WAY CASES AS SIMILAR FOLIAGE AREAS FOR COMPARISON. THE BULK OF THE MEASUREMENTS WERE MADE AT DEPRESSION ANGLES BELOW 3 DEG., ALTHOUGH A SET OF 1-WAY MEASUREMENTS WERE MADE FOR 7.4 AND 16.2 GHZ FOR A DEPRESSION ANGLE OF 29 DEG. ATTENUATION PROPERTIES, POLARIZATION RATIOS, AND INCOHERENT SPECTRAL AND CORRELATION PROPERTIES WERE INVESTIGATED AS A FUNCTION OF FREQUENCY, POLARIZATION, DEPTH OF FOLIAGE, AND REAL SPEED.**

2211818*MINK, J.W.*RAIN-ATTENUATION AND SIDE-SCATTER MEASUREMENTS OF MILLIMETER WAVES OVER SHORT PATHS*NO #*ECOM REPORT NO. 4327*JUNE 1975*AD-A012 167*RESULTS OF RAIN ATTENUATION AND SIDE SCATTER MEASUREMENTS AT MM WAVELENGTHS ARE PRESENTED THAT HAVE BEEN OBTAINED WITH A SHUTTLE PULSE TECHNIQUE. THIS REQUIRES A PATH LENGTH THROUGH RAIN OF ONLY A FEW METERS SO THAT RAINFALL RATE AND DROP SIZE DISTRIBUTION CAN BE CONSIDERED UNIFORM ALONG THIS PATH.**

212182G*DEIRMENDJIAN, D.*FOR INFRARED AND SUBMILLIMETER SCATTERING. II. ATTENUATION BY CLOUDS AND RAIN*CONTRACT NO. F44620-C-0011*NO #*FEB 1975*AD-A011 644*IN THIS SECOND PART OF OUR STUDY ON FAR IR AND SUB MM ATMOSPHERIC SCATTERING EFFECTS, WE USE THE OPTICAL CONSTANTS SURVEYED IN THE FIRST PART (DIERMENDJIAN 1974 - AD-787205) TO ESTIMATE EXTINCTION COEFFICIENTS OVER THE WAVELENGTH RANGE 12 UM TO 2.0 CM. FOR THIS PURPOSE, WE SET UP NEW ANALYTIC DROP SIZE DISTRIBUTION MODELS TO SIMULATE FOG, PRECIPITATING CLOUDS, AND RAIN CORRESPONDING TO RAIN OF 10 AND 50 MM/HR. THE RESULTS IN THE FORM OF VOLUME EXTINCTION AND ABSORPTION COEFFICIENT COMPUTED ACCORDING TO POLYDISPERSE MIE SCATTERING THEORY AT SPECIFIC WAVELENGTHS, ARE PRESENTED IN TABLES AND GRAPHICALLY IN PLOTS ALLOWING FOR ACCURATE INTERPOLATION AT ANY DESIRED WAVELENGTH WITHIN THE RANGE.**

1121818*ROGOVIN, D. AND TIGLOAR, H.*ON SPECTROSCOPIC MODELING OF THE WATER MOLECULE*CONTRACT NO. F29601-74A-0023-0002* NO #*SEPT 1976*AD-A032 448*THIS REPORT EXAMINES THE VALIDITY OF SPECTROSCOPIC MODELING TECHNIQUES DESERTING THE ROTATIONAL STRUCTURE OF HIGH LYING ROTATIONAL LEVELS OF LIGHT ASSYMETRIC ROTATORS SUCH AS WATER. PRESENT TECHNIQUES BASED ON WATSON'S ROTATIONAL HAMILTONIAN WERE FOUND TO BE INADEQUATE.**

222171H*ISHIMARUM A. AND HONG, S.T.*PROPAGATION CHARACTERISTICS OF A PULSE WAVE IN A DISCRETE TIME*CONTRACT NO. F19628-74-C-0005*NO #*MARCH 1974*AD-782-029*THE PROPAGATION CHARACTERISTICS, COHERENCE TIME, COHERENCE BANDWIDTH AND PULSE WAVEFORM OF A WAVE PASSING THROUGH A DISCRETE TIME VARYING RANDOM MEDIA RE CONSIDERED HERE. THEY ARE FORMULATED BASED ON FOLDY-TWERSLEY THEORY. USING ITS FIRST ORDER SOLUTION, EXPLICIT EXPRESSIONS APPLY TO THE CASES OF SMALL TRANSMITTING BANDWIDTHS AN/OR SHORT PROPAGATION DISTANCES. NUMERICAL CALCULATIONS ARE MADE FOR MM (40 AND 100 GHZ) PLANE AND SPHERICAL WAVES PROPAGATED THROUGH RAIN. THE RESULTS SHOW THAT THE COHERENCE TIME AND THE COHERENCE BANDWIDTH ARE QUITE DEPENDENT ON THE TYPES OF TRANSMITTING AND RECEIVING CHARACTERISTICS. WITHIN 10 MM (HR TO 100 MM/HR) PRECIPITATION, A MM PULSE WAVE SUFFERS HEAVY ATTENUATION DURING THE PATH, BUT THE MAIN PORTION OF THE RECEIVING PULSEFORM IS ESSENTIALLY UNCHANGED.**

122131E*SADJIAN, H.*ANALYTICAL STUDY OF PASSIVE TECHNIQUES FOR MEASURING ATMOSPHERI*CONTRACT NO. N6229-77-C-0058*NO #* OCT 1977*AD-A045 717*CALCULATIONS ARE PRESENTED THAT SHOW THE DEGREE OF RECOVERY OF BOTH ATMOSPHERIC WATER VAPOR AND TEMPERATURE DISTRIBUTION USING PASSIVE IR AND MICROWAVE RADIOMETRY - ASSUMING GROUND BASED RADIOMETERS. A GRADIENT TECHNIQUE IS USED TO RECOVER A TEMPERATURE PROFILE WITH 2 INVERSIONS AND A WATER VAPOR PROFILE WITH 5 INVERSIONS. THE METHOD IS APPLICABLE TO DISTRIBUTIONS TO 2 KM. CALCULATIONS ARE ALSO PRESENTED THAT SHOW THE EFFECT OF WATER VAPOR AND TEMPERATURE ON RADIO WAVE PROPAGATION AND THE EFFECT OF VISIBILITY ON THE PASSIVE METHODS. 15 REFS. AND BIBLIOGRAPHY ON RADIOMETERS, AND MM WAVE PROPAGATION.**

B61481F*ARONSON, J.R.; EMSHE, A.G.; AND STRONG, P.F.*THEORY OF ABSORPTION AND SCATTERING BY LOSSY DIELECTRIC PARTICLES* CONTRACT NO. 03-4-022-121*NO #*JULY 1975*PB-246 965*THIS REPORTS ON A NEW METHOD OF CALCULATING THE ABSORPTION AND SCATTERING OF PARTICLE-NON SPHERICAL ONES, APPLIED TO INTERPRET THE IR SPECTRA OBTAINED BY MARINER 9. THIS THEORY IS CAPABLE OF HANDLING STATISTICAL DISTRIBUTIONS OF PARTICLES OF DIFFERING SHAPES. PERHAPS THE MOST NOVEL AND IMPORTANT CONCLUSION OF THIS WORK HAS BEEN THE CONCEPT OF ENHANCED ABSORPTION BY EDGES AND SURFACE ASPHERITIES ON PARTICLES. THE PRESENT WORK IS AN ATTEMPT TO SHOW THAT THE EXTRA ABSORPTION BY EDGES, POSTULATE IN THIS WORK, IS BASED IN THEORY, THE ULTIMATE PURPOSE IS TO IMPROVE EXISTING THEORETICAL METHODS FOR TREATING THE ABSORPTION AND SCATTERING PROPERTIES OF ARBITRARY SHAPE.**

211171H*WARREN, F.G.R.*MM INVESTIGATIONS, VOL. 2. MM WAVE PROPAGATION AND ITS PREDICTIONS, PROJECT MALLARD*CONTRACT NO PG 727001-1*NO #*JAN 1969*AD-857 433*IN THIS VOLUME A SURVEY IS MADE OF AVAILABLE INFORMATION ON THE PROPAGATION OF CM AND MM WAVES, WITH EMPHASIS ON APPLICATION FOR SHORT ALL WEATHER LINKS. FACTORS AFFECTING PROPAGATION ARE REVIEWED INCLUDING INTERFERENCE AND DIFFRACTION EFFECTS, ATMOSPHERIC ABSORPTION, DUSTING, ATMOSPHERIC SCINTILLATIONS, AND THE EFFECT OF PRECIPITATION. THIS LATTER SUBJECT IS TREATED IN GREAT DETAIL INCLUDING TECHNIQUES DESCRIBED IN THE LITERATURE FOR PREDICTION OF THE DISTRIBUTION OF OCCURRENCE OF GIVEN ATTENUATION LEVELS DUE TO PRECIPITATION. PROCEDURES FOR APPLYING THIS INFORMATION TO THE PREDICTION OF MEAN SIGNAL LEVEL AND EXPECTED RANGE OF SIGNAL VARIATIONS ARE DESCRIBED. THIS HAS 53 REFERENCES, PLUS A LARGE BIBLIOGRAPHY ON ATMOSPHERIC ATTENUATION OF MM AND CM WAVES, CA 1969.**

311171C*KEELTY, J.M. AND WARREN, F.G.R.*MILLIMETER INVESTIGATIONS, PROJECT MALLARD, VOL. I, FINAL REPORT*CONTRACT NO. PG727001-1*NO #*JAN 1969*AD-857 432*A SUMMARY OF THE RESULTS AND CONCLUSIONS OF THE MALLARD TECHNIQUE SUPPORT EFFORT STUDY TD-4 ARE GIVEN IN THIS VOLUME (#1). THE MATERIAL COVERED IN THE OTHER FOUR VOLUMES IS DESCRIBED BRIEFLY. THE PURPOSE OF THE COMMUNICATION LINK WAS TO MEASURE THE ERROR RATES IN DIGITAL TRANSMISSIONS OVER A 15 AND 35 GHZ CARRIER/LINK AND THEIR CORRELATION WITH METEOROLOGICAL FACTORS. SUBSTANTIAL ATTENUATIONS WERE OBSERVED WITH WET SNOW, BUT LIMITED OCCURRENCE OF RAINFALL DURING THE OPERATING PERIOD.**

141151C*LIN, B.J.*ABSORPTION IN THE SUBMILLIMETER RANGE*NSG-74-60*NO #*DEC 15, 1965*N66-16704*WATER VAPOR ABSORPTION IS THE MOST INTENSE ABSORPTION IN THE SUB MM REGION. WITH A NEW SPECTROMETER, THE MICHELSON TYPE INTERFEROMETER, INVESTIGATIONS OF ABSORPTION CAN BE EXTENDED TO A LOWER FREQUENCY RANGE WITH BETTER RESOLUTION AND ACCURACY. AN EXPERIMENTAL SETUP IS DESCRIBED WHICH MEASURES THE WATER VAPOR ABSORPTION FROM V = 10 CM-1 TO V = 200 CM-1 (.1 CM = 1 MM TO .05 MM) AT A PATHLENGTH OF 200 FT AND PRESSURES OF 4.4 MM HG AND 1.1 MM HG. THEORIES OF THE WATER VAPOR ROTATIONAL LINE POSITIONS ARE REVIEWED. A NEWLY CONSTRICTED HIGH TEMPERATURE

SUB MM SOURCE IS ALSO DESCRIBED.**
723131F*CATOR, WILLIAM M.*ABSORPTION AND EMISSION IN THE 8-MM REGION BY OZONE IN THE UPPER ATMOSPHERE*NONR-222 (54) AND NSG-243-62*NO #*MAY 1967*AD-652-575*THE ABSORPTION OF SOLAR RADIATION AND THE EMISSION OF THE ATMOSPHERE (EFFECTIVE SKY TEMPERATURE) WERE MEASURED AT ROTATIONAL LINES OF OZONE AT 30, 056, MHZ, 36, 025 MHZ, AND 37, 830 MHZ. THE MEASUREMENTS WERE MADE POSSIBLE BY THE SPECIAL DEVELOPMENT OF A FREQUENCY SWITCHING RADIOMETER AND A GAIN COMPENSATION TECHNIQUE. THE CONTRIBUTIONS OF OZONE TO ATMOSPHERIC ABSORPTION AND EMISSION ARE EVALUATED FROM THE SOLUTION OF THE RADIATIVE TRANSFER EQUATION ON THE BASIS OF A LINE WIDTH FUNCTION OF TEMPERATURE AND PRESSURE AND THE ARDC-1957 STANDARD ATMOSPHERE; THE CONTRIBUTION OF THE WATER VAPOR AND OXYGEN ARE DETERMINED FROM THE THEORIES OF BARRETT AND CHUNG FOR H2O AND MEEKS FOR O2.**
132181C*HALL, JAMES T.*ATTENUATION OF MILLIMETER WAVELENGTH RADIATION OF GASEOUS WATER*NO #*ECOM-5097*JAN 1967*AD-650 812* THIS IS A THEORETICAL COMPUTATION FOR ABSORPTION BY WATER VAPOR BY MM AND SUB MM WAVES FOR GIVEN WATER VAPOR DENSITIES, PRESSURES, AND TEMPERATURES. THE RIGID ASSYMETRICAL TOP ROTOR APPROXIMATION FOR ALL ANGULAR MOMENTUM QUANTUM NUMBERS J LT OR = 12 IS USED WITH THE ZHERAKLIN-NAUMIR LINE SHAPE AND 1/2 WIDTH CALCULATED BY ANDERSONS THEORY. AN EQUATION IS GIVEN FOR EXTRAPOLATING ATTENUATION COEFFICIENTS TO PRESSURES AND TEMPERATURES OTHER THAN THOSE FOR WHICH CALCULATIONS WERE PERFORMED. WAVELENGTH COVERAGE - 4 CM-1 TO 100 CM-1: 26 REFERENCES.**
541131E*CHANG, SHURMAN AND LESTER, JAMES D.*ATMOSPHERIC ATTENUATION MEASUREMENTS AT 600 GHZ*NO #*FRANKFORD ARSENAL, MEMO REPORT 67-4-1*AUG 1966*AD-644 587*ATMOSPHERIC ABSORPTION IN THE 600 GHZ REGION HAS BEEN MEASURED THROUGH THE ACTUAL BY MEANS OF A DICKE TYPE SUPERHETERODYNE AUDIO-METER RECEIVER USING RECORD HARMONIC MIXING. THE AVERAGE MEASURED VALUE OF HORIZONTAL ATTENUATION WAS APPROXIMATELY 34 DB/KM/G/M3. THE VARIATION OF WATER VAPOR ABSORPTION WITH RESPECT TO WATER VAPOR DENSITY WAS ALSO INDICATED IN THE MEASURED RESULTS. THE MINIMUM DETECTABLE TEMPERATURE DIFFERENCE (DELTA T) MIN WAS OBTAINED BY CALCULATING THE RMS VALUE OF OUTPUT DEFLECTION AND THE USE OF THE CALIBRATION CURVE FOR THE RADIOMETER. THE BEST VALUE WAS 5.2 DEG K.**
C317317*STACEY, J.*ELECTRONICS RESEARCH PROGRAM. RESEARCH AND EXPERIMENTATION ON SPACE APPLICATIONS OF MILLIMETER WAVES: REPORT NO. TDR-169(3250-41)-1*CONTRACT NO.AF 04(695)-169* NO #*21 MAY 1963*AD-609 594*THIS IS A PROGRESS REPORT IN THE PLANNING AND DEVELOPMENT OF A 3.2 MM WAVELENGTH OBSERVATORY. A DESCRIPTION OF THE INSTRUMENTATION IS GIVEN AND OBSERVATIONAL GOALS ARE OUTLINED.**
511731D*WULFSBERG, K.N.*APPARENT SKY TEMPERATURES AT MILLIMETER WAVE FREQUENCIES: AFCRL-64-570*NO #*NO #*JULY 1964* A-605 813*MEASUREMENTS OF APPARENT SKY TEMPERATURES TAKEN OVER A ONE-YEAR PERIOD AT 15.17 AND 33 GHZ ARE SUMMARIZED. SKY TEMPERATURE PROFILES FOR VARIOUS METEOROLOGICAL CONDITIONS ARE PRESENTED AS WELL AS CURVES SHOWING THE PER-

CENTAGE TIME DISTRIBUTION FOR VARIOUS ZENITH ANGLES. SUCH FACTORS AS ABSORPTION AND RADIATION BY OXYGEN AND WATER VAPOR, EXTRAPOLATION OF THE DATA TO OTHER GEOGRAPHICAL AREAS, AND THE RELATION BETWEEN TOTAL ATTENUATION OF THE ATMOSPHERE AND SKY TEMPERATURE ARE DISCUSSED. A DESCRIPTION OF THE RADIOMETERS AND THE CALIBRATION TECHNIQUES ARE INCLUDED.**

621681D*SNAY, R.J.*MICROWAVE PORTION OF THE OXYGEN LINES REFRACTOMETER*CONTRACT NO. AF 19-6285-165*ESD-TR-66-65*JUNE 1966*AD-635 048*A MICROWAVE SUBSYSTEM WAS INSTALLED IN THE MITRE CORP'S REFRACTOMETER VANS AS AN INTEGRAL PART OF THE OXYGEN LINES REFRACTOMETER. IN OPERATION, TWO COHERENT FREQUENCIES, 45 AND 90 GHZ, ARE TRANSMITTED OVER A 23 KM PATH, AND THE CHANGE IN DIFFERENTIAL PHASE SHIFT IS MEASURED AT THE RECEIVER. THIS CHANGE IS AN INDUCTION OF THE REFRACTIVE QUALITIES OF THE ATMOSPHERE OVER THE PATH. THIS EQUIPMENT WAS TESTED AT A FIELD SITE ON THE LAKE WINNEPESAUKEE, NEW HAMPSHIRE REGION: TEST RESULTS AND RECOMMENDATIONS FOR IMPROVING SYSTEM SENSITIVITY AND STABILITY ARE GIVEN.**

5215817*LONG, M.W.*SUBMILLIMETER WAVES AND ASTROPHYSICS AT QUEEN MARY COLLEGE*NO #*ORNL-20-66*JUNE 1966*AD-485 456* THIS REPORT IS ON THE RESEARCH CAPABILITIES OF QUEEN MARY COLLEGE, A SCHOOL OF THE UNIVERSITIES OF LONDON IN THE AREA OF SUB MM RESEARCH. THEY DISCUSS THE KINDS OF SUB MM RESEARCH GOING ON (CA 1965) AND THE INSTRUMENTATION BEING USED.**

531181B*HOFFMAN, L.A. AND WINTROUB, M.J.*PROPAGATION FACTORS AT 3.2 MILLIMETERS*CONTRACT NO. AF 04(695)-469*NO #* OCT 1965*AD-474 398*USING A 15-FT PREUSSON PAROFOLIC ANTENNA SYSTEM, ABSORPTION MEASUREMENTS AT 3.2 MM INDICATE THAT THE VAN VLECK-WEISSKOPF THEORY FOR COLLISION BROADENED LINES SATISFACTORILY ACCOUNTS FOR THE ABSORPTION THROUGH THE CLEAR ATMOSPHERE, IF ONE USES THE LINE BREADTH CONSTANTS FOR O2 AND H2O EXPERIMENTALLY DETERMINED AT OTHER WAVELENGTHS. THIN LAYERS OF CLOUDS AND FOG HAVE A NEGLIGIBLE EFFECT ON THE PROPAGATION, WHEREAS THICK CLOUDS AND RAIN CAN CAUSE APPRECIABLE ATTENUATION.**

B31281A*HOFER, R.*REFLECTIONS AND EMISSION PROPERTIES OF NATURAL AND ARTIFICIAL MATERIALS AT 3 MM WAVELENGTH (IN GERMAN)*NO #*BERN UNIVERSITY, CH-3000-BERN*NOV 4, 1975*N76-10826*THE THEORY OF SCATTERING UNFOLDS AND THE CONNECTION BETWEEN EMISSION AND REFLECTIONS IS ABLE TO BE WRITTEN EXPERIMENTALLY IN TERMS OF THE REFLECTION MEASUREMENT. THE MEASURED REFLECTION COEFFICIENT AT 3 MM WAVELENGTH WILL BE GIVEN AS A FUNCTION OF THE ANGLE OF INCIDENCE FOR WATER, OIL FILM, ON WATER, STRETCHED METAL PLATE, SAND, LOAM, BRICK, SAND, HUMUS, FIR WOOD, SNOW.**

212431F*EDISON, ALLEN R.*CALCULATED CLOUD CONTRIBUTION TO SKY TEMPERATURES AT MILLIMETER-WAVE F*CONTRACT NO. MIPR-R65-15-AMC-0091*NBS REPORT NO 9138*FEB 1966*AD-479 293*THE CONTRIBUTION OF WATER AND ICE CLOUDS TO ZENITH TEMPERATURES IN THE FREQUENCY RANGE FROM 10 TO 100 GHZ IS CALCULATED USING REASONABLE MODELS. IT IS SHOWN THAT RADIATION DUE TO ABSORPTION BY WATER VAPOR AND CLOUD DROPLETS MAY CON-

TRIBUTE FROM 1 TO OVER 100 DEG K TO THE APPARENT SKY TEMPERATURE. SCATTERING FROM CLOUD DROPLETS IS OF NEGLIGIBLE IMPORTANCE OVER THE FREQUENCY RANGE CONSIDERED. A CLOUD DROPLET SIZE DISTRIBUTION OF THE FORM AR(SIXTH POWER)EXP (-BR) IS USED IN THE CALCULATIONS. THE DROPLET RADIUS IS CRITICAL BECAUSE OF THE R(CUBE) AND R(SIXTH POWER) VARIATION RESPECTIVE IN THE ABSORPTION AND SCATTERING CROSS SECTIONS.**

622381F*VAN VLECK, J.H. AND HUBER, D.L.*ABSORPTION, EMISSION AND LINE BREADTHS; A SEMI-HISTORICAL PERSPECTIVE*NO #*REVIEWS OF MODERN PHYSICS, VOL. 49, NO. 4, 939-959*OCT 1977*NO #*THE DEVELOPMENT OF THE THEORY OF THE INTERACTION OF ELECTROMAGNETIC RADIATION WITH ATOMS AND MOLECULES IS OUTLINED. A FULLY CLASSICAL ANALYSIS OF ABSORPTION AND EMISSION IS FORMULATED IN WHICH PARTICULAR ATTENTION IS PAID TO QUESTIONS OF DETAILED BALANCE AND TO THE SUM RULES OBEYED BY THE SUSCEPTIBILITY. COLLISION BROADENING IS INTRODUCED THROUGH TIME-DEPENDENT DIPOLE MOMENT CORRELATION MODELS ARE GIVEN. THE CORRESPONDING QUANTUM MECHANICAL ANALYSIS IS PRESENTED WITH EMPHASIS ON THE POINTS IN COMMON WITH THE CLASSICAL APPROACH. THE IMPORTANCE OF CORRESPONDENCE PRINCIPLES IN BRIDGING THE GAP BETWEEN CLASSICAL AND QUANTUM MECHANICAL THEORIES IS STRESSED.**

B12583C*OPPENHEIM, IRWIN; SHEELER, KURT E. AND WEIS, GEORGE H.*STOCHASTIC THEORY OF MULTISTATE RELAXATION PROCESSES*NO #*ADVANCED MOL. RELAXATION PROCESSES, VOL. 1, 13-68*1967-68*NO #*THE AUTHORS PRESENT HERE A BRIEF AND SELECTED REVIEW OF THE STOCHASTIC THEORY OF MULTISTATE RELAXATION PROCESSES. TITLES IN THIS PAPER ARE MARKOV PROCESSES, DERIVATION OF THE MASTER EQUATION, GENERAL PROPERTIES OF THE MASTER EQUATION, THE FOKKER PLANCK EQUATION, FIRST PASSAGE TIME PROBLEMS, AND SELECTED APPLICATIONS -- HARMONIC OSCILLATOR RELAXATION IN A HEAT BATH, RELAXTION OF TWO INTERACTING SYSTEMS OF HARMONIC OSCILLATION, RELAXATION OF RALEIGH AND LORENTZ GAS.**

9325818*SMYTH, CHARLES P.*DIELECTRIC RELAXATION BY INTRAMOLECULAR MECHANISMS*NO #*ADVAN. MOL. RELAXATION PROCESSES, VOL. 1, 1-11*1967-68*NO #*THIS IS A DISCUSSION OF EFFECTS OF INTERNAL FIELDS IN A DIELECTRIC, AND THE RELATIONSHIP BETWEEN INTER AND INTRA MOLECULAR MOTIONS AND THEIR CORRESPONDING RELAXATION TIMES. SOME DATA IS DISCUSSED ABOUT MM WAVE ABSORPTION HYDROCARBONS - H-HEPTANE, CYCLOHEXANE, BENZENE, AND CCL4.**

B12584K*MEIXNER, J.*CONSISTENCY OF THE ONSAGER-CASIMIR RECIPROCAL RELATIONS*NO #*ADVAN. MOL. RELAXATION PROCESSES, VOL. 5, 319-331*1973*NO #*THIS IS A THEORETICAL DISCUSSION ON THE CONSISTENCY (AND VALIDITY) OF THE ONSAGER-CASIMIR RECIPROCAL RELATIONS. THESE RELATIONSHIPS - FOR DIELECTRIC PHENOMENA, RELATE COMPONENTS OF A DIELECTRIC STRESS TENSOR TO EACH OTHER IN EIG - HERMITIAN CONGUGATE OF (EJI . IN A GENERAL SENSE, THE ONSAGER RECIPROCAL RELATIONS FORM A LINE FOR THE ENTIRE DISCIPLINE OF MACROSCOPIC IRREVERSIBLE THERMODYNAMICS.**

B12585C*MEIXNER, J.*NEW THERMODYNAMIC THEORY OF RELAXATION PHENOMENA*NO #*ADVAN. MOL. RELAXATION PROCESSES, VOL. 3,

227-234*1972*NO #*THIS IS A GENERAL, THEORETICAL DISCUSSION ON A NEW LOOK AT RELAXATION PROCESSES, WHICH EXIST IN MATERIAL MEDIA AS ACOUSTIC, ELASTIC, DIELECTRIC, MAGNETOACOUSTIC ETC. PHENOMENA. ALL OF THESE ARE "EFFECTS" WHICH OCCUR AS A RESULT OF AN EXTERNAL FIELD ON A MEDIA, WHETHER IT IS A STRAIN, ELECTRIC, MAGNETIC...ETC. THESE EFFECTS "FOLLOW" THE CAUSES IN THE CONSTITUTIVE EQUATIONS; FOR EXAMPLE, IN THE CASE OF A DIELECTRIC, THE DISPLACEMENT D(W) = E(IW)E(W), WITH E(IW) THE COMPLEX DIELECTRIC "CONSTANT" AND E(W) THE CAUSATIVE FIELD.**

C417A27*GALLAGHER, J.J.; STRAUCH, R.G.; CUPP, R.E.*EXCITATION AND DETECTION TECHNIQUES FOR MM WAVES*DR3821*MARCH 1964 *AD434001*THE OBJECT OF THIS CONTRACT IS TO INVESTIGATE THE EXCITATION AND DETECTION TECHNIQUES FOR MOLECULAR MM WAVE TRANSITIONS WHICH CAN BE USED TO DEVELOP A FREQUENCY STANDARD OPERATING IN THE REGION OF 1 MM. DURING THE PAST QUARTER, H2S ELECTRIC RESONANCE HAS BEEN OBSERVED**

D217A1C*NO NAME*MM WAVE AMPLIFICATION BY RESONANCE SATURATION IN GASES*CONTRACT NO. AF 30(602)2744*RADC-TDR-63-562*MAR 1964*AD-434 764*THE POWER SATURATED RESONANCE ABSORPTION OF A GAS (HCN) HAS BEEN USED TO ACHIEVE MM WAVE AMPLIFICATION. EXPERIMENTS WERE CONDUCTED AT ROOM TEMPERATURE IN BOTH A TRAVELING WAVE SYSTEM AND IN A RESONANT CAVITY. THE RESULTS ARE IN GOOD AGREEMENT WITH THEORY. A GAIN OF 20 DB WAS OBTAINED WITH A 6-INCH LONG BY 3/4-INCH DIAMETER CYLINDRICAL CAVITY AT 86 GHZ. AN ANALYSIS INDICATES THAT THE INHERENT NOISE FIGURE SHOULD BE 7 DB; MEASUREMENTS SHOWED THAT IT WAS 25 DB, WHICH WAS SET BY THE SENSITIVITY OF THE TEST EQUIPMENT.**

C13175C*GREEN, AGUSTUS H.*MM TECHNIQUE EVALUATION OF GUIDANCE DATA ATTENUATION BY EXHAUST PLUMES*NO #*RE-TR-63-31, REVISED* 26 MAR 1964*AD-435 539*THIS ARTICLE DESCRIBES THE INSTRUMENTATION TO MEASURE THE MM WAVE TRANSMISSION IN THE PLASMA/EXHAUST OF ROCKET MOTORS AT 76 GHZ AND 10 GHZ. THEORY LEADING UP TO THE PLASMA ABSORPTION EQUATIONS ARE DEVELOPED, AND RESONANCE FREQUENCIES DEFINED. BY MEASURING THE ATTENUATION CONSTANT AND THE PHASE CONSTANT AS SELECTED FREQUENCIES, THE COLLISION FREQUENCY AND THE ELECTRON DENSITY MAY BE DETERMINED. ANY OF THESE RESULTS INDICATES WHICH TYPES OF PROPELLANTS RENDER GOOD PROPAGATION CHARACTERISTICS.**

921581K*CROSSLEY, J.*DIELECTRIC RELAXATION AND INTERMOLECULAR ROTATION IN ALIPHATIC KETONES*NO #*CANADIAN J. CHEM., VOL. 51, 2571-2675*1973*NO #*CROSSLEY MEASURES THE DIELECTRIC CONSTANTS OF ALIPHATIC AND AROMATIC KELONES IN CYCLOHEXANE, H-HERADECANE, DECALIN AND PARAFFIN OIL-CYCLOHEXANE MIXTURES AT 25 DEG C IN THE FREQUENCY RANGE 1-145 GHZ. THE RESULTS WERE ANALYZED IN TERMS OF COLE-COLE PLOTS. THE RELAXATIONTIMES AND THEIR VICOSITY DEPENDENCE WERE DEALT WITH IN TERMS OF INTERMOLECULAR AND WHOLE MOLECULAR ROTATIONAL MECHANISMS.**

321151C*GLUSHNER, V.G.; SLUTSHER, B.D.; AND FIRKELSTELYN, M.I.*

MEASUREMENT OF THE ATTENUATION OF RADIO WAVES IN THE 8 MM BAND IN SEA ICE AND FRESH WATER ICE AND SNOW*NO #*RADIO FIZITEN, VOL. 19(1976), NO. 9, 1305-1307(USSR)*9 DEC 1976*AD-B019-605L (FSTC 1068-76)*THIS REPORT ON THE MEASUREMENT OF ATTENUATION OF RADIO WAVES THROUGH SEA ICE, FRESH WATER ICE, AND SNOW AT 8.2 MM (36.8 GHZ). THE "TWO THICKNESS" METHOD WAS USED TO EVALUATE THE ATTENUATION. FOR SEA ICE, WITH SALINITY 2.4 PERCENT, TEMPERATURE -22.4 DEG C, THE ATTENUATION WAS 111-150 DB/METER. FOR FRESH WATER ICE, THE ATTENUATION WAS 13 DB/METER. FOR SNOW, OF DENSITY .21-.32 GM/CM3, IT WAS 31 TO 37 DB/METER.**

224111I*RICHARD, VICTOR W. AND KAMMERER, JOHN E.*RAIN BACKSCATTER MEASUREMENTS AND THEORY AT MILLIMETER WAVELENGTHS* NO #*US ARMY BALLISTICS RESEARCH LAB., ABERDEEN PROVING GROUND, MD 21005 (BRL-1838)*OCT 1975*AD-B003 173L*AN EXPERIMENT WAS PERFORMED TO MEASURE THE PROPERTIES OF RAIN BACKSCATTER BETWEEN 0 AND 100 GHZ OVER A RANGE OF RAIN INTENSITIES FROM DRIZZLES UP TO 100 MM/HR. RAIN BACKSCATTER AMPLITUDE AND FLUCTUATION MEASUREMENTS WERE MADE SIMULTANEOUSLY AT 10, 35, 70, AND 95 GHZ WITH PULSE RADARS FOR BOTH LINEAR AND CIRCULAR POLARIZATION ALONG WITH RAINFALL RATE AND DROPSIZE MEASUREMENTS. THE MEASURED RAIN BACKSCATTER VS RAINFALL RATE DATA ARE COMPARED WITH VARIOUS THEORIES, INCLUDING SOVIET AUTHORS. A BIBLIOGRAPHY IS INCLUDED. RESULTS:
1) REDUCTION IN RANGE BY RAIN BACKSCATTER IS SEVERE AT 35 GHZ, COMPARED WITH BOTH HIGHER AND LOWER FREQUENCIES.
2) THERE IS A DECREASE IN RAIN BACKSCATTER AT 20 GHZ.
3) A RADAR OF A GIVEN DISK SIZE CAN SEE BETTER AT 95 GHZ THAN AT 20 OR 35 GHZ. HAS GOOD RAIN CELL STATISTICS.**

213171B*ROGERS, R.R.*STATISTICAL RAINSTORM MODELS: THEIR THEORETICAL AND PHYSICAL FOUNDATIONS*NO #*IEEETRANS. ANTENNA AND PROP. AP....547-566*JULY 1976*NO #*FROM PROPAGATION EXPERIMENTS AND STUDIES OF THE FINE RULE STRUCTURE OF RAIN, DATA ARE BECOMING AVAILABLE IN THE HORIZONTAL EXTENT OF HEAVY RAIN AREAS AND THE WAY THIS STRUCTURE INFLUENCES SYSTEM PERFORMANCES. THESE DATA ARE USED TO FORMULATE STATISTICAL RAINFORM MODELS THAT PERMIT PREDICTION OF THE PERFORMANCE OF SINGLE PATH AND PATH DIVERSITY SYSTEM. THE CURRENT STATUS OF RAIN CELL MODELS IS REVIEWED AND SUGGESTIONS FOR FUTURE RESEARCH ARE OFFERED.**

2131728*CRANE, ROBERT K.*ATTENUATION DUE TO RAIN, A MINI-REVIEW*NO #*IEEE TRANS. ANTENNAS AND PROPAGATION AP-23, NO. 4SEPT 1975*NO #*THIS IS A BRIEF REVIEW PAPER ON RAIN-CAUSED ATTENUATION. THE PAPER REVIEW PROGRESS ON THE DEVELOPMENT AND VERIFICATION OF A THEORY OF RAIN-CAUSED ATTENUATION, AND CONSIDERS THE STATISTICAL MODELS REQUIRED TO PREDICT ATTENUATION. 15-35 GHZ DATA CONSIDERED MOSTLY, BUT HAS REVIEW OF MM AND SUB MM PROPAGATION LITERATURE.**

9411816*CHANTRY, G.W.; GEBBIE, H.A.; LASSIER, B.; AND SYLLIE, G.*SUB MM WAVE SPECTRUM OF NON POLAR LIQUID AND CRYSTAL*NO #*NATURE, VOL. 244, 163-165*APRIL 8, 1967*NO #* THIS REPORTS ON THE ABSORPTION SPECTRUM OF CCL4 AT 130 DEG K (SOLID) AND AT 300 DEG K (LIQUID), FOR MM WAVELENGTHS BETWEEN 20 CM-1 AND 100 CM-1.**

842761D*ANDREEV, B.A.; BURENIN, A.V.; KARYAKIN, E.N.;

KURPNOV, A.F.; AND SHAPIN, S.M.*SUBMILLIMETER WAVE SPECTRUM AND MOLECULAR CONSTANTS OF N2O*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 62, 125-148*1976*NO #*THE SUB MM WAVE SPECTRUM OF THE N2O MOLECULE HAS BEEN INVESTIGATED INTHE 375-565 GHZ FREQUENCY RANGE WITH A SENSITIVITY BETTER THAN 10-8 CM-1. THE MEASURED FREQUENCIES INCLUDE 161 LINES WITH INTENSITIES GAMMA GE 10-6 CM-1 BELONGING TO 22 SPECTRONOMICALLY DIFFERENT SPECIES OF THE MOLECULE)SPECIFICALLY, THE GROUND AND SOME EXCITED VIBRATIONAL STATES OF THE FIVE MOST ABUNDANT ISOTOPIC SPECIES OF THE MOLECULE IN NATURAL ABUNDANCE)WITH A STATISTICAL AND SYSTEMATIC ERROR OF THE ORDER OF MAGNITUDE 10-8.**

862781A*BILLINGSLEY, FRANK P. II.*CALCULATED VIBRATION-ROTATION INTENSITIES FOR NO(X2II)*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 61, 53-70*1976*NO #*THE ABSOLUTE INTENSITIES OF THE VIBRATIONAL ROTATION TRANSITION IN THE GROUND STATE OF NO HAVE BEEN CALCULATED FOR VIBRATION LEVELS UP TO V = 20 AND TOTAL ANGULAR MOMENTUM STATES UP TO J = 35.5. THE TREATMENT FULLY PROVIDES FOR VIBRATION-ROTATION COUPLING AND SPIN UNCOUPLING EFFECTS, AND EMPLOYS AN ACCURATE THEORETICAL REPRESENTATION OF THE ELECTRONIC DIPOLE MOMENT FUNCTION FO NO.**

D417A1A*PLANT, T.K.; NEWMAN, L.A; DANIELEWICZ, E.J.; DETEMPLE, T.A.; AND COLEMAN, P.D.*HIGH POWER OPTICALLY PUMPED FOR INFRARED LASERS*NO #*IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. MTT-22, NO. 12, 988-990*DEC 1974*NO #*THIS ARTICLE DESCRIBES LASER ACTION IN SEVERAL GASES OPTICALLY PUMPED WITH A CO2 TRANSVERSELY EXCITED ATMOSPHERIC PRESSURE (TEA) LASER. A MAXIMUM OF FIR POWER OF 100 KW WAS OBSERVED FROM CH3F AT 496 UM. CHARACTERISTICS OF THE SYSTEM AND POSSIBILITIES OF SCALING TO HIGHER POWERS ARE DISCUSSED.**

C21781A*MICROWAVE DEVICES LABORATORY, UNIVERSITY OF UTAH, QUARTERLY REPORT, JAN 1, 1963 TO MAR 31, 1963*CONTRACT NO. AF 64(647)-745*MDL-Q4*MAR 31, 1963*AD-412 237*THE BROAD PURPOSE OF THE RESEARCH ACTIVITY REPORTED HERE IS TO EXTEND THE USEFUL FREQUENCY SPECTRUM INTO THE RANGE FROM UWAVE TO OPTICAL FREQUENCIES AND TO IMPROVE EXISTING DEVICES AND TECHNIQUES INTO THE UWAVE SPECTRUM. AT PRESENT THIS OBJECTIVE IS BEING PURSUED: STUDIES OF ELECTRON BEAM DEVICES, SOLID STATE DEVICES, AND PLASMAS. SOME WORK ON X AND K BAND TRANSMISSION OF ROCKET PLUMES WAS REPORTED.**

B13581E*BERG, DANIEL, COMMITTEE CHAIRMAN*DIGEST OF LITERATURE ON DIELECTRICS, VOL. 26, 1962*NO #*PUBLICATION 1139, NATIONAL ACADEMY OF SCIENCE, LIBRARY OF CONGRESS NO. 45-33864*A963*AD-424 943*THIS IS A DIGEST OF LITERATURE ON DIELECTRICS PUBLISHED IN 1962. CHAPTER TITLES OF THIS REVIEW WORK ARE: 1) INSTRUMENTATION AND MEASUREMENTS; 2) TABLES OF DIELECTRIC CONSTANTS, DIPOLE MOMENTS AND DIELECTRIC RELAXATION TIMES; 3) MOLECULAR AND IONIC INTERACTIONS IN DIELECTRICS; 4) CONDUCTION IN SOLID DIELECTRICS; 5) THE BREAKDOWN OF DIELECTRICS; 6) FERROELECTRIC AND PREZOELECTRIC MATERIALS; 7) HIGH POLYMERIC MATERIALS; 8) INSULATING FILMS AND FIBROUS MATERIALS; 9) INSULATING LIQUIDS AND APPLICATIONS; 10) INORGANIC INSULATION; 11) APPLICA-

TIONS; PUBLICATION OF THE CONFERENCE.**
131171D*COATS, G.T.; BOND, R.A.; AND TOLBERT, C.W.*PROPAGATION MEASUREMENT IN THE VICINITY OF THE 183 GHZ WATER VAPOR LASER*NO #*REPORT 7-20*FEB 5 1962*AD-272 287*RECENT INVESTIGATION OF ATMOSPHERIC WATER VAPOR ABSORPTION AT FREQUENCIES OF 172, 183.6, AND 194 GHZ HAVE PRODUCED VALUES OF 1.755, 4.41 AND .881 DB/KM KEV GM/M3 RESPECTIVELY. IT WAS FOUND THAT THE VAN VLECK-WEISSHOPF EQUATION PREDICTS THE SAME ATTENUATION IF IT IS ASSUMED THAT THE MEASURED FREQUENCY WAS IN ERROR BY 3.7 GHZ. UNDER THIS ASSUMPTION, A LINE BREADTH CONSTANT OF 0.18 CM-1 IS REQUIRED FOR THE 183.6 WATER VAPOR LINE, AND THE PEAK ABSORPTION FOR THIS LINE IS CALCULATED TO BE 5.78 DB/KM PER GM/M3 FOR AN ABSORPTION FACTOR OF 0.02736.**
D317A1A*CHANG, T.Y.*OPTICALLY PUMPED SUBMILLIMETER-WAVE SOURCES*NO #*IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL.MTT-22, NO. 12, 983-988*DEC 1974*NO #*OPTICAL PUMPING OF POLAR MOLECULES BY MEANS OF IR LASERS IS EXPECTED TO LEAD TO 1000'S OF LASER LINES THROUGHOUT THE SUB MM WAVE SPECTRUM. ALREADY, 282 NEW LASER LINES BETWEEN 34 UM AND 1.814 MM IN 18 DIFFERENT MOLECULES HAVE BEEN REPORTED. VERY STABLE CW OPERATION, VERY HIGH PULSED OUTPUT, LINEAR POLARIZATION, HIGH GAIN, AND MANY OTHER ADVANTAGES OVER DISCHARGE EXCITATION ARE OFFERED.**
9325829*WILLIAMS, GRAHAM*CORRELATION FUNCTION TREATMENTS OF THE DIELECTYRIC RELAXATION OF MODEL SYSTEMS CAPABLE OF CHEMICAL RELAXATION*NO #*ADVAN. MOL. RELAXATION PROCESSES, VOL. 1, 409-422*1970*NO #*THIS IS A THEORETICAL TREATMENT OF DIELECTRIC RELAXATION OF A GENERAL SYSTEM IN CHEMICAL EQUILIBRIUM -- INVOLVING CHEMICAL REACTIONS. THE SPECIFIC MODELS ANALYZED BY SCHWARTZ FOR OPPOSING UNIMOLECULAR REACTIONS, AND FOR OPPOSING BIMOLECULAR REACTIONS ARE TREATED USING THE CORRELATION FUNCTION APPROACH.**
9315419*AFSAR, M.N. AND CHANTRY, G.W.*PRECISE DIELECTRIC MEASUREMENTS OF LOW LOSS MATERIALS AT MM AND SUB MM WAVERLENGTHS*NO #*IEEE TRANS. MICROWAVE, MTT-25, NO. 6*JUNE 1977*NO #*TRANSMISSION DISPERSIVE FOURIER TRANSFORM SPECTROMETRY (DFTS) HAS BEEN USED FOR THE MEASUREMENTS OF BOTH REAL AND IMAGINARY PART OF THE COMPLEX INDEX OF REFRACTION OF LOW LOSS MATERIALS AT MM AND SUB MM WAVELENGTHS. THE MATERIALS INVESTIGATED WERE CIS AND TRANS DECALIN AND POLYPROPYLENE.**
2416516*CHAMBERLAIN, J.; ZEFAR, M.S.; AND HASTED, J.B.*DIRECT MEASUREMENT OF REFRACTION SPECTRUM OF LIQUID WATER AT SUBMILLIMETER WAVELENGTHS*NO #*NATURE PHYSICAL SCIENCE, VOL. 243, 116-117*JUNE 18, 1973*NO #*A MICHELSON INTERFEROMETER IS USED TO MEASURE THE COMPLEX INDEX OF REFRACTION OF LIQUID WATER FROM .5 MM TO 0.1 MM IN WAVELENGTHS.**
232181C*SOKOLOV, A.V. AND SUKHONIN, YE.V.*ATTENUATION OF SUBMILLIMETER RADIO WAVES IN RAIN*NO #*RADIO ENGINEERING AND ELECTRONIC PHYSICS, VOL. 15, NO. 12, 2167-2171*1970*NO #*THE RESULTS OF A THEORETICAL COMPUTATION OF ATTENUATION OF RADIO WAVES IN THE 0.1-2.0 MM RANGE ARE PRESENTED; THE COMPUTATIONS ARE MADE TAKING ACCOUNT OF NEW EXPERIMENTAL DATA IN THE COMPLEX INDEX OF LIQUID WATER WITH DROP SIZE

DISTRIBUTIONS GIVEN BY BEST AND POLYAKOVA. IT IS SHOWN THAT THE COMPUTATION OF ATTENUATION IN RAIN WITH ATTENUATION LESS THAN 10-12 MM/HR, BASED ON VIGOROUS MIE THEORY, ARE IN SATISFACTORY AGREEMENT WITH THE EXPERIMENTAL DATA AT THE WAVELENGTH OF 0.96 MM.**

241181C*BABKIN, YU.S.; ZIMIN, N.N.; IZYAMOV, A.O.; ISKHAKOV, I.A.; SOKOLOV, A.V.; STROGNANOV, L.I.; SUKHONIN, YE.V.; AND SHABELIA, G.YE.*MEASUREMENTS OF ATTENUATION IN RAIN OVER 1 KM PATH AT A WAVELENGTH OF 0.96 MM*NO #*RADIO ENGINEERING AND ELECTRONIC PHYSICS, VOL. 15, NO. 12, 2164-2166*1970*NO #*THE RESULTS OF AN EXPERIMENTAL STUDY OF THE ATTENUATION IN RAIN IN SUMMER THUNDERSTORM ARE PRESENTED FOR A WAVELENGTH OF 0.96 MM OVER A PATH OF 1 KM IN LENGTH. THE APPARATUS AND THE PROCEDURE OF MEASUREMENTS USED IN THE STUDY ARE DESCRIBED BRIEFLY. IT IS SHOWN THAT COMPARED TO A WAVELENGTH OF 8.6 MM THE ATTENUATION AT 9.6 MM IS LARGER ROUGHLY BY A FACTOR OF 2.5-3.**

213171G*FANG, D.J. AND HARRIS, J.M.*A NEW METHOD OF ESTIMATING MICROWAVE ATTENUATION OVER A SLANT PROPAGATION PATH BASED ON RAIN GAUGE DATA*NO #*IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION*MAY 1976*NO #*A BASIC PROBLEM IN ESTIMATING THE UWAVE ATTENUATION OVER A SATELLITE-EARTH PROPAGATION PATH ON THE BASIS OF RAIN GAUGE DATA IS THAT, FOR A GIVEN PROPAGATION EVENT, THE ATTENUATION AND THE RAINFALL RECORDS VERY OFTEN DO NOT HAVE CONSISTENT DETAILED CORRELATION. SUCH INCONSISTENCIES CAN BE GREATLY REDUCED IF THE FALLING SPEED OF THE RAINDROPS, 2-9 M/SEC FOR DROP SIZES OF 0.05-.7 CM IS TAKEN INTO ACCOUNT. ADJUSTMENTS IN TIME AND DROP SIZE SPECTRUM ARE NEEDED FOR DATA COLLECTED FROM FIELD RAIN GAUGES TO REALIZE THE ACTUAL RAINFALL ALONG THE SLANT PATH FOR CORRELATING RAIN GAUGE DATA WITH MEASURED SATELLITE SIGNALS. DATA IS SPECIFICALLY FOR 20 GHZ: EXPERIMENT DISCUSSED IS ATS-6, 20/30 GHZ PROPAGATION EXPERIMENT.**

212111A*ROZENBERG, V.I.*RADAR CHARACTERISTICS OF RAIN IN SUBMILLIMETER RANGE*NO #*RADIO ENGINEERING AND ELECTRONIC PHYSICS, VOL. 15, NO. 12, 2157-2163*1970*NO #*EFFECTIVE ATTENUATION AND BACKSCATTERING CROSS SECTIONS OF PRECIPITATION ARE INVESTIGATED IN THE WAVELENGTH RANGE 0.03 CM TO 10 CM. THE EFFECT OF THE DROP SIZE DISTRIBUTION (MARSHALL PALMER), DIELECTRIC CONSTANT, TEMPERATURE AND WAVELENGTH ON THE RIGOROUS RESULTS OF RADAR CHARACTERISTICS OF RAIN, DRIZZLE, AND RAIN WITH DRIZZLE IS INVESTIGATED. A REVIEW OF THE PUBLICATION IS PRESENTED.**

221181C*MCCORMICK, G.C.*PROPAGATION THROUGH A PRECIPITATION MEDIUM: THEORY AND MEASUREMENT*NO #*IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, 266-748*MARCH 1975, ERRATA SEPT 1975, P. 748*NO #*THE THEORY OF PROPAGATION THROUGH A PRECIPITATION MEDIUM IS BASED HERE ON THE DIFFERENTIAL PROPAGATING CONSTANT AND TWO ADDITIONAL COMPLEX CONSTANTS. THE LATTER REDUCE TO A SINGLE REAL PARAMETER, "THE CANTING ANGLE," FOR SOME SIMPLE MODELS, FOR EXAMPLE, FOR A POPULATION OF EQUI-ORIENTED SYMMETRICAL SCATTERERS. IN A UNIFORM MEDIUM THE CONSTANTS ARE CLOSELY RELATED TO THE ELEMENTS OF AN EQUIVALENT PERMITTIVITY TENSOR. IT IS SHOWN THAT THE PARAMETER CAN BE DETERMINED FROM A SEQUENCE OF DEPOLARI-

ZATION MEASUREMENTS.**
212181H*PARIS, JACK F.*TRANSFER OF THERMAL MICROWAVES IN THE ATMOSPHERE, VOLS. I AND II*NO #*TEXAS A & M UNIVERSITY, PHD THESIS, DEPARTMENT OF METEOROLOGY, GRANT NO. NGR-44-001-098*MAY 1971*NO #*THE MIE THEORY IS USED TO DETERMINE THE ABSORPTION AND SCATTERING PROPERTIES OF LIQUID HYDROMETERS AT 27MICROWAVE FREQUENCIES FROM 500 MHZ (60 CM-WAVELENGTH) TO 60 GHZ (5 MM-WAVELENGTH). BASED ON THE MARSHALL-PALMER DISTRIBUTION OF DROP SIZE, REGRESSION EQUATIONS ARE DEVELOPED AS A FUNCTION OF ITS TEMPERATURE AND CONTENT OF LIQUID WATER. MEASUREMENTS OF THE DIELECTRIC CONSTANT OF WATER AND AQUEOUS SODIUM CHLORIDE BY LANE AND SAXTON ARE USED TO FORM REGRESSION EQUATIONS FOR THE DIELECTRIC CONSTANT OF WATER AS A FUNCTION OF ITS TEMPERATURE AND SALINITY. THESE EQUATIONS, AND THE FRESNE EQUATIONS FOR REFLECTION ARE USED TO COMPUTE THE POLARIZED COMPONENTS OF THE THERMAL EMISSION OF SEA WATER FOR A WIDE RANGE OF SEA TEMPERATURE, SEA SALINITY MICROWAVE FREQUENCIES, AND ANGLES OF VIEWING.**
632761B*ZHELTONOG, K.S. AND KOPELOVICH, L.YE.*ON THE POSSIBILITY OF INVESTIGATING THE ALTITUDE PROFILE OF THE ATMOSPHERIC ABSORPTION COEFFICIENT AT A WAVELENGTH OF 2.53 MM BY A RADIOMETRIC METHOD*NO #*RADIO ENG. AND ELECTRONIC PHYSICS, 110-112*AUG 21, 1976*NO #*ON THE BASIC OF MODEL CALCULATION, THIS PAPER DISCUSSES THE POSSIBILITY OF OBTAINING INFORMATION ABOUT THE ALTITUDE PROFILE OF GAMMA AT 2.543 MM WAVELENGTH (AN OXYGEN ABSORPTION LINE) BY MEASURING THE ALTITUDE BEHAVIOR OF THE DIFFERENCE BETWEEN THE ZENITH BRIGHTNESS TEMPERATURE AND THE KINETIC TEMPERATURE OF THE ATMOSPHERE.**
6221717*OTT, RANDOLPH AND THOMPSON, M.C.*CHARACTERISTICS OF A RADIO LINK IN THE 55 TO 65 GHZ RANGE*NO #*IEEE TRANS. ANTENNAE AND PROP., 873-877*NOV 1976*NO #*THE LONG-TERM VARIABILITY (100'S OF SECONDS) OF THE TRANSFER FUNCTION FOR A RADIO LINK IN THE 55-65 GHZ RANGE IS EXAMINED BY COMPUTING THE DIFFERENTIAL ATTENUATION AND DIFFERENTIAL PHASE WITH RESPECT TO CHANGES IN PRESSURE AND TEMPERATURE.**
6231816*MEEKS, M.L. AND LILLEY, A.E.*THE MICROAVE SPECTRUM OF OXYGEN IN THE EARTH'S ATMOSPHERE*NO #*JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 68, NO. 6, 1683-1703*MARCH 15, 1963*NO #*THIS IS A LONG REVIEW ARTICLE ON THE MICROWAVE SPECTRUM OF O2 IN THE EARTH'S ATMOSPHERE, CA 1963. PRINCIPLE ABSORPTION REGION AT 60 FHZ.**
9211816*MICHIELSEN-EFFINGER, JANINE*MICROAVE SPECTRUM OF ETHYL ALCOHOL*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 35, 489-491*1970*NO #*THIS IS A DISCUSSION OF EXPERIMENTAL VERIFICATION OF THE EXISTENCE OF TWO STABLE SOURCES OF ETHYL ALCOHOL BY OBSERVATION THE 8 MM WAVELENGTH REGION WITH A MICROWAVE SPECTROMETER.**
6221816*WELCH, WILLIAM M. AND MIZUSHIMA, MASATAKA*MOLECULAR PARAMETERS OF THE O2 MOLECULE*NO #*PHYSICAL REVIEW A, VOL. 5, NO. 6, 2692-2695*JUNE 1972*NO #*BY ANALYZING ALL EXISTING FREQUENCY DATA ON THE O2 MOLECULE IN UWAVE, SUB MM AND I.R. SPECTROSCOPY, A NEW SET OF VALUES FOR MOLECULAR PARAMETERS IS OBTAINED.**
8511617*DOWLING, JEROME M.*THE ROTATION-INVERSION OF SPECTRUM

OF AMMONIA*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 27, 527-538*1968*NO #*THE ROTATION-INVERSION SPECTRUM OF NH3 HAS BEEN OBSERVED IN THE WAVE NUMBER REGION 35 CM-1 AND 240 CM-1 WITH A RESOLUTION OF 0.08 CM-1. THE K-SPLITTING (DUE PRIMARILY TO CENTRIFUGAL DISTORTION) IS EXTENSIVE AND MANY LINES DUE TO SINGLE TRANSITIONS ARE OBSERVED.**

8411618*HELMINGER, PAUL; DELUCIA, F.C.; AND GORDY, WALTER* ROTATIONAL SPECTRA OF NH3 AND ND3 IN THE 0.5-MM WAVELENGTH REGION*NO #*JOURNAL OFMOLECULAR SPECTROSCOPY, VOL. 39, 94-97* 1971*NO #*FOR ND3 THE TWO INVERSION COMPONENTS OF THE J=L,2 TRANSITIONS OF 14ND3 AND 15ND3 AT 0.49 MM WAVELENGTH HAVE BEEN MEASURED, AND FOR NH3, THE J=0,1 TRANSITIONS OF 14NH3 AND 15NH3 AT 0.52 MM HAVE BEEN MEASURED WITH HIGH PRESSURES.**

832161B*FREUND, S.M.*MILLIMETERWAVE ROTATION - INVERSION TRANSITION OF 14NH3 AND 15NH3 IN THE V2-STATE*NO #* JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 48, 183-184*1973* NO #*FROM THE ANALYSIS OF THE LASER-STARK SPECTRUM OF THE V2 FUNDAMENTAL BAND OF 14NH3, SHIMIZN NOTICED THAT THE LOWER INVERSION OF THE J=2, K=1 ROTATIONAL STATE AND THE UPPER INVERSION LEVEL OF THE J=1, K=1 STATE ARE ACCIDENTALLY CLOSE IN ENERGY IN THE V2 STATE AND PREDICTED THE ENERGY SPACING OF THE TWO LEVELS TO BE 134.7 TO .3 GHZ. IN THIS LETTER, DIRECT MM WAVE OBSERVATIONS OF THIS TRANSITION ARE REPORTED.**

B335818*VAUGHN, WORTH E., EDITOR AND JOHORI, GYON P., ASSOC. ED.*DIGEST OF LITERATURE ON DIELECTRICS, VOL. 37 FOR 1973* NO #*COMMITTEE ON DIGEST OF LITERATURE OF THE CONFERENCE ON ELECTRICAL INSULATION AND DIELECTRIC PHENOMENA,NATIONAL RESEARCH COUNCIL, NATIONAL ACADEMY OF SCIENCES*1975*NO $* THIS DIGEST IN PARTICULAR CONTAINS A LOT OF REFERENCES ON ABSORPTION OF MM WAVES IN HYDROCARBON COMPOUNDS AND IS A GOOD SOURCE ON "EXOTIC GASES" - COMBUSTION PRODUCTS, ETC.**

B335828*BUDENSTEIN, PAUL P.*DIGEST OF LITERATURE ON DIELECTRICS FOR 1972: VOL.36*NO #*NATURAL ACADEMY OF SCIENCES, WASHINGTON, D.C., LIBRARY OF CONGRESS NO. 45-33864*1974* NO #*THIS IS A DIGEST/BIBLIOGRAPHY ON DIELECTRICS PUBLISHED APPARENTLY ANNUALLY BY THE COMMITTEE ON DIGEST OF LITERATURE OF THE CONFERENCE ON ELECTRICAL INSULATION AND DIELECTRIC PHENOMENA DIVISION OF ENGINEERING, NATIONAL RESEARCH COUNCIL, MUCH MATERIAL. THIS SERIES CONTAINS REVIEWS OF THE LITERATURE ON DIELECTRIC AND DIELECTRIC PHENOMENA IN SOLIDS, LIQUID AND GASES OF DIRECT INTEREST PLUS THOSE WORKING IN MM WAVE AREA.**

B62581A*GEICK, REINHART*APPLICATION OF SUBMILLIMETER SPECTROSCOPY TO MAGNETIC EXCITATIONS*NO #*IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. MTT-25, NO. 6, 500-505*JUNE 1977*NO #*THIS ARTICLE GIVES A BRIEF TREATMENT OF FERRO- AND ANTIFERROMAGNETIC RESONANCE ABSORPTION. THE FREQUENCIES ARE MOSTLY IN THE FAR IR SPECTRUM. 1, 2, AND 3 DIMENSIONAL MAGNETIC CRYSTALS ARE DISCUSSED, RELATING TO THEIR EXCHANGE INTERACTIONS. SOME OF THE "3-D" CRYSTALS DISCUSSED ARE MNO, NIO, COO, AND SEVERAL MN, NI AND CO FLUORIDES. 39 REFS. **

B615819*SMITH, DONALD R. AND LOEWENSTEIN, ERNEST V.*OPTICAL

CONSTANTS OF METAL OXIDES IN THE FAR INFRARED REGION*NO #*
APPLIED OPTICS, VOL. 15, NO. 4, 859-861*APRIL 1976*NO #*
THIS ARTICLE REPORTS ON THE OPTICAL CONSTANTS OF FOUR
METAL OXIDES; THESE ARE NICKEL OXIDE, RUTILE, IN CRYSTALLINE
FORM, AND ALUMINUM OXIDE (LUCALOX, SINTERED), AND YTTRIUM,
THORIUM OXIDE (YTTRALOX, SINTERED). THE OPTICAL CONSTANTS
FOR LUCALOX AND YTTRALOX WERE MEASURED AT 300 DEG K;THOSE
OF NIO AND TIO2 AT 1.5 DEG K.**
B625829*BHAR, GOPAL C.*REFRACTIVE INDEX INTERPOLATION IN
PHASE-MATCHING*NO #*APPLIED OPTICS, VOL. 15, NO. 2, 305-307*
FEB 1976*NO #*THIS ARTICLE GIVES THE SELLMEIER COEFFICIENTS
FOR SOME NON LINEAR (IR) MATERIALS: COEFFICIENTS A,B,C,D,E,
OF THE EQUATION N2 = A + B/(1 - C/LAMBDA**2) + D/(1 -
E/LAMBDA**2) ARE GIVEN FOR TE1(4 - 30 UM), ALPHA HGS(.6-11.0
UM), CASE (1.01-12, 22.0 UM), AG GA SZ(.49 - 12.0 UM), AND
FOUR OTHER TERNARY NON LINEAR CRYSTALS. 19 REFS. TO
ARTICLES IN INDEX OF REFRACTION FOR MATERIALS IN IR.**
133181E*SHIMUBUKURO, FRED I. AND EPSTEIN, EUGENE*ATTENUATION
AND EMISSION OF THE ATMOSPHERE AT 3.3 MM*NO #*IEEE AP-18,
NO. 4, 485-489*JULY 1970*NO #*FOUR EMPIRICAL RELATIONSHIPS
HAVE BEEN DEVELOP3D TO DETERMINE THE ATTENUATION WHEN RADIO
MEASUREMENTS ARE NOT AVAILABLE. THESE INCLUDE: THE
RELATIONSHIPS INVOLVE THE TOTAL AMOUNT OF PRECIPITABLE WATER
IN THE ATMOSPHERE (DETERMINED FROM RADIO SONDE DATA), WATER
VAPOR DENSITY OF THE SURFACE, IR SPECTRAL HYGROMETER OB-
SERVATIONS OF THE SUN, AND 3.3 MM MEASUREMENTS OF DIFFER-
ENTIAL ATMOSPHERIC EMISSION. WHEN SOLAR RADIO MEASUREMENTS
CANNOT BE MADE, THE DIFFERENTIAL EMISSION TECHNIQUE IS PRE-
FERRED MEANS OF DETERMINING THE ATTENUATION BECAUSE IT CAN BE
CARRIED OUT AT ANY TIME AND RESULTS ARE IMMEDIATELY AVAILABLE.
12 REFS.**
B61583D*MCCARTHY, D.E.*REFLECTION AND TRANSMISSION MEASURE-
MENTS IN THE FAR INFRARED*NO #*APPLIED OPTICS, VOL. 10,
NO. 11, 2539-2541*NOV. 1971*NO #*REFLECTION AND TRANSMISSION
MEASUREMENTS OVER THE 800-33 CM-1(12.5 UM-300 UM) REGION
ARE PRESENTED FOR SEVERAL MATERIALS. DATA INCLUDE THE
SPECTRAL REFLECTANCE OF ADP, KDP, NACL, KBR, CSBR, CSI,
TLBR, TLCL, AND KRSB. CURVES OF THE EXTERNAL TRANSMITTANCE
OF SAMPLES OF KD-F, TEFLON, GE, MILLIPORE FILTERS AND A KODAK
WRATTEN FILTER ARE INCLUDED. DATA ARE GIVEN ON THE FUNDA-
MENTAL ABSORPTION FREQUENCIES OF MGO, LIF,TIO2, KBR,
TLCL, AND TLI. DOUBLE BEAM SPECTRA PHOTOMETERS WERE USED
FOR MAKING THE MEASUREMENTS, ALL THE CRYSTALS REPORTED
HERE WERE SYNTHETIC.**
B615848*WIJNBERGEN, J.J. AND KELLY, A.A.*FAR INFRARED TRANS-
MISSION AND REFLECTION OF IRTRAN 1 THROUGH IRTRAN 6 AT
LOW TEMPERATURES*NO #*APPLIED OPTICS, VOL. 13, NO. 11,
2716-2718*NOV 1974*NO #*TRANSMISSION AND REFLECTION
MEASUREMENTS IN THE IR BETWEEN 340 AND 40 CM-1 ARE PRE-
SENTED FOR IRTRANS 1-6. MEASUREMENTS HAVE BEEN PERFORMED
AT ROOM TEMPERATURE, LIQUID N2 AND LIQUID HE TEMPERA-
TURES.**
B615859*SHOTTS,W.J. AND SIEVERS, A.J.*LOW-TEMPERATURE FAR-
INFRARED WINDOWS*NO #*APPLIED OPTICS, VOL. 13, NO. 12,
2773-2774*DEC 1974*NO #*WINDOWS OF POLYETHYLENE AND GER-

MANIUM ARE SUGGESTED FOR USE AS FAR IR MEASUREMENTS, FOR WAVENUMBERS LESS THAN 700 CM-1. POLYETHYLENE .1 MM THICK TRANSMITS MORE THAN 80 PERCENT FOR WAVENUMBERS LESS THAN 700 CM-1. GERMANIUM (1 MM THICK) TRANSMITS AT LEAST 20 PERCENT, EVEN AT THE 350 CM-1 LATTICE ABSORPTION BAND, AND MORE FOR LONGER WAVELENGTHS.**

132171C*ULABY, FAWWAZ, T.*ATMOSPHERIC ABSORPTION OF RADIO WAVES BETWEEN 150 AND 350 GHZ*NO #*IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. AP-18, NO. 4, 479-485*JULY 1970*NO #* THIS PAPER COMPARES SEVERAL FORMS FOR THE ABSORPTION LINE SHAPES FOR ATMOSPHERIC GASES AS APPLIED TO FREQUENCIES BE- TWEEN 150 AND 350 GHZ. THE CONTRIBUTIONS OF VARIOUS LINES TO THE ABSORPTION IN THIS FREQUENCY RANGE ARE EXAMINED. EQUATIONS ARE PRESENTED FOR DIRECT CALCULATION OF ATTENUA- TION AS A FUNCTION OF PRESSURE TEMPERATURE AND WATER VAPOR DENSITY. RESULTS OF THESE CALCULATIONS SHOULD BE IN GOOD AGREEMENT NEAR THE 183 AND 323 GHZ (WATER VAPOR) ABSORPTION LINES, BUT WILL BE SUBSTANTIALLY LOW IN THE WINDOWS.**

151761B*WINTHER, F.*THE ROTATIONAL SPECTRUM OF WATER BETWEEN 650 AND 50 CM-1 H2180 AND H2170 IN NATURAL ABUNDANCE*NO #* JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 65, 408-419*1977* NO #*IN THE FAR IR SPECTRUM OF WATER, 121 H2180 AND 48 H2170 PURE ROTATIONAL LINES HAVE BEEN IDENTIFIED. FROM THE LINE FREQUENCIES AND A MINIMUM NUMBER OF LITERATURE VALUES OF NEAR IR ROTATION-VIBRATIONAL TRANSACTIONS AND LINES FROM MICROWAVE SPECTRA. FOR LOW J LEVELS, THE AGREEMENT WITH EARLIER CALCULATIONS FROM OTHER MICROWAVE LINES AND NEAR IR RESULTS IS WITHIN EXPERIMENTAL ERROR, BUT DEVIATIONS UP TO 0.6 CM-1 ARE FOUND FOR HIGH J, HIGH KA LEVELS.**

622181A*STRAITON, ARCHIE W.*THE ABSORPTION AND RERADIATION OF RADIO WAVES BY OXYGEN AND WATER VAPOR IN THE ATMO- SPHERE*NO #*IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, 595-597*JULY 1975*NO #*THIS IS A REVIEW ARTICLE ON THE INTERACTION OF RADIO WAVES WITH OXYGEN AND WATER VAPOR IN THE ATMOSPHERE. TOPICS ARE: CENTER FREQUENCY, LINE STRENGTHS, LINE SHAPES, TEMPERATURE AND PRESSURE DEPENDENCE, OXYGEN ATTENUATION IN THE ATMOSPHERE, WATER VAPOR ATTENUA- TION IN THE ATMOSPHERE, RE-RADIATION BY ATMOSPHERIC GASES, WINDOWS AND WALLS. 11 REFS. **

1411429*AUGASON, G.C.; MORD, A.J.; WITTEBORN, F.D.; ERICKSON, E.F.; SWIFT, C.D.; CAROFF, L.J.; AND KUNZ, L.W.*WATER VAPOR ABSORPTION SPECTRA OF THE UPPER ATMOSPHERE (45-185 CM-1)* NO #*APPLIED OPTICS, VOL. 14, NO. 9, 2146-2150*SEPT 1975* NO #*THE FAR IR NIGHT TIME ABSORPTION SPECTRUM OF THE EARTH'S ATMOSPHERE ABOVE 14 KM IS DETERMINED FROM OBSERVATIONS OF THE BRIGHT MOON. THE SPECTRA WAS OBTAINED USING A MICHELSON INTERFEROMETER ATTACHED TO A 30 CM TELESCOPE ABOARD A HIGH ALTITUDE JET AIRCRAFT.**

B311817*MON, K.K. AND SIEVERS, A.J.*PLEXIGLAS: A CONVENIENT TRANSMISSION MATERIAL FOR THE FIR SPECTRAL REGION*NO #*APPLIED OPTICS, VOL. 14, NO. 5, 1054-1055*MAY 1975*NO #*THIS ARTICLE REPORTS ON THE ABSORPTION CONSTANT IN CM-1 OF FUSED SILICA (SIO2) AND PLEXIGLASS AT 300 DEG K AND 4.2 DEG K IN THE WAVE NUMBER BAND 2-50 CM-1. (60 GHZ - 1500 GHZ).**

A61181G*FICHER, KLAUS*MASS ABSORPTION INDICES OF VARIOUS TYPES OF NATURAL AEROSOL PARTICLES IN THE INFRARED*NO #*APPLIED OPTICS, VOL. 14, NO. 12, 2851-2856*DEC 1975*NO #*THE MASS ABSORPTION INDEX OF AEROSOL PARTICLES HAS BEEN MEASURED IN THE 2-17 UM WAVELENGTH REGION. THE MEASUREMENTS WERE PERFORMED ON FILMS OF AEROSOL PARTICLES THAT WERE COLLECTED BY AN AUTOMATIC JET IMPACTOR AT POLLUTED AND VARIOUS UNCONTAMINATED SITES. ALL BUT MARINE AEROSOLS POSSESS STRONG ABSORPTION BANDS IN THE TRANSPARENT PART OF THE ATMOSPHERIC LONG WAVE SPECTRUM, INDICATING THE MARKED INFLUENCE OF AEROSOL PARTICLES ON THE RADIATION BUDGET OF THE ATMOSPHERE. PLACES WHERE THE AEROSOLS WERE COLLECTED WERE MAINZ, GERMANY (URBAN), (MARINE) WEST COAST OF IRELAND, (MARINE)(CONTINENTAL) WEST COAST OF IRELAND, (MOUNTAIN) JUNGFRAU JOCH, SWITZERLAND, AND THREE SITES, NEGER DESERT, ISRAEL.**

C41141H*FLEMING, J.W. AND CHAMBERLAIN, JOHN*HIGH RESOLUTION FOR IR FOURIER TRANSFORM SPECTROSCOPY USING MICHELSON INTERFEROMETERS WITH AND WITHOUT COLLIMATION.*NO #*INFRARED PHYSICS, VOL. 14, 277-292*1974*NO #*A-2 BEAM INTERFEROMETER OF THE MICHELSON TYPE HAS BEEN USED TO MEASURE THE ABSORPTION SPECTRA OF CO, N2O, AND NO IN THE SPATIAL REGION 15-40 CM-1 AT A RESOLUTION OF .05 CM-1. THE INTERFEROMETER WAS USED IN BOTH A COLLIMATED AND UNCOLLIMATED MODE AND A DETAILED COMPARISON OF MEASURED WAVENUMBERS WAS MADE FOR CARBON MONOXIDE. THE WAVENUMBER CONTRACTIONS IN THE COLLIMATED INTERFEROMETER ARE AS EXPECTED FROM FINITE APERTURE CONSIDERATIONS, AND THE LARGER CONTRACTIONS OBSERVED WITH THE UNCOLLIMATED INTERFEROMETER CAN BE RELATED TO THE GEOMETRY OF THE COLLECTING OPTICS. ONCE THE WAVENUMBER SCALE GIVEN BY THE MEASUREMENTS MADE ON NO AND N2O SHOW AGREEMENT WITH EXPECTED POSITION FOR CO1 CM-1. 26 REFS. **

141131E*RYADOV, V.Y.; FURASHOV, N.I.; AND SKORONOV, G.A.*MEASUREMENT OF ATMOSPHERIC TRANSPARENCIES IN THE 0.87 MM WAVE REGION*CONTRACT NAS5-3760*NASA-TT-F-8931*27 JULY 1964*N64-27134*ABSORPTION IN THE ATMOSPHERIC TRANSPARENCY WINDOW, CENTERED AT THE MEAN WAVELENGTH LAMBDA = .87 MM, IS MEASURED BY A RADIOMETER USING THE SUN AS A SOURCE, IN THE SPECTRAL INTERVAL OF 0.9 CM-1. THE MEAN WATER VAPOR ABSORPTION FACTOR IN THIS BAND, CONVERTED TO MOISTURE RHO = 7.5/G/M3, AND THE ATMOSPHERIC PRESSURE AT SEA LEVEL, GAVE 10.4 DB/KM. AT THE SAME TIME, THE MINIMUM VALUE OF THE ABSORPTION FACTOR IN THIS WINDOW, OBTAINED FOR .97 MM WAVELENGTH, CONSTITUTED 8.7 DB/KM. COMPARISON IS MADE BETWEEN THE RESULTS OF THE EXPERIMENT AND THE THEORETICAL DATA.**

321181B*BATTLES, J.W. AND CRANE, D.E.*ATTENUATION OF A K A BAND ENERGY BY SNOW AND ICE*NO #*NOLC REPORT 670*10 AUG 1966*AD-638 303*MEASUREMENTS OF THE ATTENUATION OF E & M ENERGY BY SNOW AND THE REFLECTION OF RADIATION FROM SNOW AND ICE WERE MADE BY USING AN INTERFEROMETER AND MANUFACTURED SNOW AND ICE IN AN ENVIRONMENTAL CHAMBER UNDER CLOSELY CONTROLLED CONDITIONS. THE AMBIENT TEMPERATURE WAS HELD AT -14 DEG F FOR ALL MEASUREMENTS. SNOW AND ICE ATTENUATION

AND REFLECTION MEASUREMENTS ARE TABULATED FOR VARIOUS SNOW DENSITIES COVERING THE RANGE 32-39 GHZ. RESULTS SHOW THAT PACKED SNOW AND GREATER DENSITY PRODUCED LESS ATTENUATION.**

C225815*BATTLES, J.W.*MM INTERFEROMETER*NO #*NOL CERONA*NO #*AD-603 544*THIS ARTICLE DESCRIBES A NEW MM WAVE INTERFEROMETER, BASED ON FROOME'S, THAT IS DESIGNED TO MEASURE THE COMPLEX DIELECTRIC CONSTANT OF VARIOUS MATERIALS AT MM WAVELENGTHS (35-75 GHZ).**

2311716*FRENKEL, L.*PROPAGATION OF MM AND SUB MM WAVES, FINAL REPORT*NAS 5W-963*MARTIN COMPANY*1965*N65-29374*THIS REPORT GIVES RESULTS OF LABORATORY EXPERIMENTS OF TRANSMISSION OF MM WAVES APPARENTLY 150-300 GHZ, IN WATER VAPOR AND OTHER ATMOSPHERIC GASES, AND SOME MEASUREMENTS OF THE DIELECTRIC CONSTANT ON THESE.**

2231719*USIKOV, A.YA.; GERMAN, V.L.; AND VAKSER, I.KH.*INVESTIGATION OF ABSORPTION AND SCATTERING OF MM WAVES IN PRECIPITATIONS II (TRANSLATED)*NO #*UKRAINSKII FIZICHNII ZHURNAL, VOL. 6, NO. 5, 618-641 (NASA TT-F-11,913)*1968*N68-35837*THIS PAPER PRESENTS EXPERIMENTAL DATA ON THE DAMPING OF RADIO WAVES RANGING IN LENGTH FROM 8.15 TO 2.17 MM IN RAIN AND THE BASIC RESULTS OF A THEORETICAL STUDY OF THE SCATTERING AND ABSORPTION OF MM RADIO WAVES IN PRECIPITATIONS.**

2111716*DERR, VERNON E.*INVESTIGATIONS OF THE PROPAGATION OF MM WAVES, MONTHLY LETTER REPORT, 1-31 OCT 1964*NO #*MARTIN COMPANY*JUNE 21, 1965*N65-23707*THIS REPORTS ON SOME MEASUREMENTS OF AN ATMOSPHERIC WATER VAPOR ABSORPTION LINE AT A HARMONIC OF 74.6668 GHZ. PROBLEMS WITH THEIR EXPERIMENTAL HARDWARE WERE DISCUSSED.**

212748*SMITH, IRA, EDITOR*FIRST QUARTERLY REPORT FOR MM COMMUNICATIONS PROPAGATION PROGRAM (1 NOV 1964 - 1 FEB 65)*NO #*NASA CR-75623*1966*N66-27949*THIS IS THE FIRST QUARTERLY REPORT FOR AN 8-MONTH STUDY PROGRAM TO DESIGN EXPERIMENTS TO DETERMINE THE EFFECTS OF THE PROPAGATION MEDIUM - TO LOW (200 NM), MEDIUM ALTITUDE (6000 NM) AND SYNCHRONOUS COMMUNICATION SATELLITE, IN THE 15-35 GHZ BAND.**

212173A*SMITH, IRA, EDITOR*FINAL REPORT, VOLUME II, FOR MM COMMUNICATION PROPAGATION PROGRAM (1 NOV 1964 - 1 NOV 1965)*CONTRACT NO. NAS5-9523*NASA CR-76095*NOV 1964*N66-30164*THIS DOCUMENT IS VOLUME II OF THE FINAL REPORT FOR THE MM COMMUNICATION PROGRAM BEING PERFORMED TO STUDY THE REQUIREMENTS FOR THE DESIGN OF EXPERIMENTS TO DETERMINE THE EFFECTS OF THE PROPAGATION MEDIUM ON MM SPACE-EARTH PATHS, FOR BOTH LOW ALTITUDES (200 NM) MEDIUM ALTITUDE (6000 NM) AND SYNCHRONOUS ALTITUDE (22,300 NM) SATELLITES.**

561121I*FAZIO, G.G.*A 102-CM BALLOON-BORNE TELESCOPE FOR FAR IR ASTRONOMY*NO #*OPTICAL ENGINEERING, VOL. 16, NO. 6, 551-557(NGR22-007-270*NOV-DEC 1977*NO #*THE CENTER FOR ASTROPHYSICS - UNIVERSITY OF ARIZONA. BALLOON-BORNE INERTIALLY GUIDED, 102 CM TELESCOPE WAS DESIGNED TO PERFORM PHOTOMETRY AND HIGH RESOLUTION MAPPING OF FAR IR (40-250 UM) CELESTIAL SOURCES. TO DATE THE TELESCOPE HAS NOW BEEN FLOWN AND SUCCESSFULLY RECOVERED A TOTAL OF 10

TIMES. SIX OF THE FLIGHTS HAVE PRODUCED USEFUL ASTRONOMICAL DATA, RESULTING IN MORE THAN 40 HOURS OF OBSERVATIONS OF NUMEROUS OBJECTS, SUCH AS HII REGIONS, DARK CLOUDS, MOLECULAR CLOUDS, GALAXIES, THE GALACTIC CENTER, PLANETS, AND AN ASTEROID. MAPS WITH A RESOLUTION OF 1 ARE MIN FWHM HAVE BEEN ACHIEVED WITH ABSOLUTE POSITION ACCURACIES OF PLUS OR MINUS 10 ARINER. THE RMS NOISE EQUIVALENT FLUX DENSITY OF THE SYSTEM IS APPROXIMATELY 70 JY/(HZ)1/2 FROM THE LAUNCH SITE IN TEXAS, SOURCES AS FAR SOUTH AS -50 DEGS DECLINATION CAN BE OBSERVED.**

513162H*NO #*THE INFLUENCE OF THE ATMOSPHERE ON REMOTE SENSING MEASUREMENTS, VOL. 3*ESRO CONTRACT NO. 1838/72 PP*HSD TD-7400, HAWKER SIDDLEY DYNAMICS*DEC 1973*N74-20988*ATMOSPHERIC INFLUENCES ON REMOTE SENSING ARE REVIEWED FOR WAVELENGTHS IN THE MICROWAVE AND RADIO REGION (15 & 35 GHZ). THE EARTH'S ATMOSPHERE IS DESCRIBED AND THE IMPORTANT PHYSICAL PROCESSES OCCURRING WITHIN IT ARE EXPLAINED. THESE PROCESSES INCLUDE: GASEOUS ABSORPTION AND EMISSION; PARTICLE SCATTERING AND ABSORPTION AND EMISSION; REFRACTION AND TURBULENCE. THE INFLUENCES OF THESE ATMOSPHERIC PROCESSES ON PASSIVE AND ACTIVE SENSORS MOUNTED ON VARIOUS PLATFORMS ARE REVIEWED. FINALLY, CORRECTIVE TECHNIQUES, TO RESTORE ATMOSPHERIC DEGRADED DATA TO AN ERROR-FREE FORM, IS EXAMINED. THIS VOLUME SPECIFICALLY GIVES DETAILS OF STUDY 2, "THE INFLUENCE OF THE ATMOSPHERE ON REMOTE SENSING AT UWAVE AND RADIO WAVELENGTHS.**

563161D*NO #*THE INFLUENCE OF THE ATMOSPHERE ON REMOTE SENSING MEASUREMENTS, VOL. 2*ESRO CONTRACT NO. 1837/72 PP*HSD-TD-7400, HAWKER SIDDLEY DYNAMICS*DEC 1973*N74-20987*THIS SECOND VOLUME (OF 4) GIVES DETAILS ON REMOTE SENSING OF WAVELENGTHS FROM UV TO FAR IR: THE EARTH'S ATMOSPHERE IS DESCRIBED AND THE IMPORTANT PHYSICAL PROCESSES OCCURRING WITHIN IT ARE EXPLAINED. THESE PROCESSES INCLUDE: GASEOUS ABSORPTION AND EMISSION; PARTICLE SCATTERING AND ABSORPTION AND EMISSION; REFRACTION AND TURBULENCE. THE INFLUENCES OF THESE ATMOSPHERIC PROCESSES ON PASSIVE AND ACTIVE SENSORS MOUNTED ON VARIOUS PLATFORMS ARE REVIEWED. FINALLY, CORRECTIVE TECNIQUES, TO RESTORE ATMOSPHERIC DEGRADED DATA TO AN ERROR-FREE FRAME, IS EXAMINED.**

5131819*BLOOR, D.*BIBLIOGRAPHY OF FAR IR SPECTROSCOPY*NO #*INFRARED PHYSICS, VOL. 10, 1-55*1970*NO #*THIS BIBLIOGRAPHY CONTAINS REFERENCES TO SPECTROSCOPIC STUDIES WITHIN THE REGION 50-2000 UM (.05-2 MM) WAVELENGTH. A NUMBER OF PAPERS ARE INCLUDED DEALING WITH TECHNIQUES AND THEORETICAL DISCUSSIONS, APPLICABLE IN THIS REGION. PAPERS ARE LISTED BY YEAR OF PUBLICATION AND THE FIRST AUTHOR'S NAME IN ALPHABETICAL ORDER. AN INDEX WITH GENERAL CATEGORIZATION IS INCLUDED.**

1411818*STEPHENSON, D.A. AND STRAUCH, R.G.*WATER VAPOR SPECTRUM NEAR 600 GHZ*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 35, 494-495*1970*NO #*THIS LETTER REPORTS ON THE OBSERVATION OF ABSORPTION LINES OF H2O AND D2O AT FREQUENCIES NEAR 600 GHZ. FOR H2O, THE FREQUENCY OF THE TRANSITION 1(0,1) GOING TO 1(1,0) LINE WAS 556.9358

GHZ. IN D2O, THE FREQUENCY OF THE TRANSITION 0(0,0)
GOING TO 1(1,1) LINE AS 607.3496 MHZ.**
813511K*GAYDUK, V.I.; LOSKUTOV, V.S.; AND SEKISTOV, V.N.*
NONLINEAR THEORY OF COMPLEX DIELECTRIC CONSTANT OF DIPOLE
GASES*NO #*RADIO ENGINEERING AND ELECTRONIC PHYSICS, VOL.
21, 5-17*NOV 1976*NO #*AN EXPRESSION FOR THE REAL AND
IMAGINARY PART OF A COMPLEX DIELECTRIC CONSTANT E = E'-JE"
IS DERIVED ON THE BASIS OF A COMPLEX POWER THEOREM. THE
COMPLEX IMPEDANCE OF A MATERIAL IS OBTAINED AS A FUNCTION
OF MICROPARTICLES. THIS THEORY IS APPLIED TO AN ENSEMBLE
OF ROTATING PARTICLES IN A MICROWAVE FIELD. THE ROTATION
IS RARELY INTERRUPTED BY COLLISIONS BETWEEN THE PARTICLES
IN A UWAVE FIELD. THE ROTATION IS RARELY INTERRUPTED BY
COLLISIONS BETWEEN THE PARTICLES. A DEPENDENCE OF E' AND
E" ON SIGNAL MAGNITUDE IS DERIVED WHICH INDICATES THE
PRESENCE OF A "BRIGHTENING" OF THE MATERIAL, WHICH IS
EXPRESSED IN TERMS OF KNOWN MICROSCOPIC PARAMETERS OF
MOLECULAR SPINS (ROTATORS) AND MACROSCOPIC PARAMETERS OF
THE MATERIAL. THE THEORY IS APPLIED TO NH3 GAS AT 12 MM
PRESSURE AND 1.8 CM WAVELENGTH; NONLINEAR EFFECTS ARE
SEEN AT 20 UWATTS IN A CAVITY.**
151181 *RABACHE, P. AND REBROURS, B.*SPECTRAL ANALYSIS OF
ABSORPTION COEFFICIENT OF H2O, O3, AND O2 IN THE FAR IR
IN THE STRATOSPHERE*NO #*INFRARED PHYSICS, VOL. 15, 179-
188*1975*NO #*IN THIS ARTICLE THE AUTHORS MAKE A COMPARISON
OF THE MOLECULAR ABSORPTION COEFFICIENTS OF THE THREE
FUNDAMENTAL CONSTITUENTS WHICH ABSORB AND EMIT ENERGY IN
THE STRATOSPHERE BETWEEN 0 AND 200 CM-1. THE SPECTRAL
RESPONSE SHOWS CLEARLY THAT FOR ALTITUDES ABOVE 16 KM,
OZONE ABSORBS A SIGNIFICANT PART OF THE RADIATION. 21
REFS. **
5511816*LOMBARDINI, P.P.; MELCHIORRI, F.; SALIO, C.; AND
RALL'AGNOLA, L.*ATMOSPHERIC TRANSMITTANCE IN THE FAR IR AT
TESTA GRIGA*NO #*INFRARED PHYSICS, VOL. 15, 73-78*1975*
NO #*ATMOSPHERIC TRANSMITTANCE IN THE BAND 300-2000 UM WAS
MEASURED IN THE FAR IR SOLAR OBSERVATORY OF TESTA GRIGA,
3980 M ABOVE STANDARD, SEA LEVEL.**
B41581A*BIRCH, J.R.; HARDING, A.F.; CROSS, N.R.; AND FULLER,
D.W.E.*TEMPERATURE VARIATION OF THE SUBMILLIMETER WAVE-
LENGTH OPTICAL CONSTANTS OF SODA-LIME-SILICA GLASS*NO #*
INFRARED PHYSICS, VOL. 16, 421-422*1976*NO #*THE OPTICAL
CONSTANTS OF SODA-LIME GLASS ARE DESCRIBED FROM 10 TO
45 CM-1 FOR TEMPERATURES OF 1.8, 4.2 AND 293 DEG K.
THE POWER ABSORPTION COEFFICIENT CHANGES FROM A WAVENUMBER-
SPONSORED DEPENDENCE AT 293 DEG K TO AN ALMOST CUBIC DE-
PENDENCE AT 1.8 K, WHILE THE REFRACTIVE INDEX FALLS FROM
A MEAN VALUE OF 2.586 AT 293 DEG K TO 2.51 AT 1.8 DEG K.**
B411817*ALVAREZ, J.A.; JENNINGS, R.E.; ET AL.*FAR I.R. MEA-
SUREMENTS OF SELECTED OPTICAL MATERIALS AT 1.6 DEG K*NO #*
INFRARED PHYSICS, VOL. 15, 45-49*1975*NO #*MEASUREMENTS AT
1.6 DEG K OF THE TRANSMITTANCE AND REFRACTIVE INDEX OF
QUARTZ, POLYETHYLENE, POLY TETRA FLUOROETHYLENE HAVE BEEN
MADE USING A MICHELSON INTERFEROMETER OPERATING IN THE
PHASE MODULATED MODE.**
B21171E*VEL'MIN, V.A.; KORETS, V.F.; ET AL.*SOME EFFECTS

DURING THE PASSAGE OF RADIO WAVES (8 MM) THROUGH THE REGION OF AN EXPLOSION*NO #*ZHARMAL POKLADNOP MEKHANILII I TEKHNICHEVSKOY FIZIKI (IN RUSSIAN), NO. 2, 136-139 (JPRS-53334 - TRANSLATION)*1971*NO #*A PROPAGATION EXPERIMENT AT 8 MM WAVELENGTH WAS CONDUCTED: 10-52 GM OF TG 50/50 EXPLOSIVE WERE SET OFF BETWEEN A 8 MM RECEIVER AND TRANSMITTER HORN SET. BEAMWIDTH WAS 16 DEG, 1/2 POWER, INTER-ANTENNAE DISTANCE WAS 230 CM. THE SIGNAL STRENGTH OSCILLATES AS A FUNCTION OF THE MASS OF EXPLOSIVE (PERIODS IN MICROSECONDS), FOR 10, 25, AND 52 GM OF EXPLOSIVE. THE RECEIVED SIGNAL CAN BE ANALYZED IN TERMS OF DIFFRACTION OFF OF THE RADII OF SURFACES ON WHICH DIFFRACTION TAKES PLACE AT THE MOMENT TK.**

8111617*LAUGHTON, D.; FREUND, S.M.; AND OKAI, T.*DELTA K = PLUS OR MINUS 3 "FORBIDDEN" INFRARED TRANSITIONS IN THE V2-BAND OF NH3*NO #*JOURNAL OF MOLECULAR SPECTROSCOPY, VOL. 62, 263-270*1976*NO #*DELTA K = I3 "FORBIDDEN" VIBRATION-ROTATION TRANSITIONS IN THE V2 BAND OF N2 HAVE BEEN MEASURED USING IR-UWAVE TWO PHOTON SPECTROSCOPY AND LASER STARK SPECTROSCOPY.**

6221841*GREENBAUM, M.*A STUDY OF MM AND SUB MM ATTENUATION AND DISPERSION IN THE EARTH'S ATMOSPHERE*CONTRACT NO. DAAH01-74-C-0419*NO #*15 AUG 1975*AD-A015 544*A SUMMARY IS PRESENTED OF NEW CALCULATIONS OF ATMOSPHERIC ABSORPTION LINE PARAMETERS AND OF A START PATH ABSORPTION MODEL (SLAM) INTENDED FOR USE IN THE MM AND SUB MM WAVE SPECTRAL REGION RESULTS OF A LITERATURE SEARCH CONCERNING ALTITUDE DEPENDENT ATTENUATION AND DISPERSION IN THIS REGION, AS WELL AS WEATHER DEPENDENT SCATTERING AND FADING STRENGTHS, ARE ALSO SUMMARIZED. RECOMMENDATIONS ARE GIVEN FOR REDUCING UNCERTAINTIES IN THE MODEL PREDICTION. A LIST OF 318 ABSORPTION LINES OF THE MOLECULAR O2 ISOTOPES OF PRINCIPAL CONCERN IN ATMOSPHERIC TRANSMISSION BELOW 300 CM-1 IS INCLUDED, TOGETHER WITH THEIR INTEGRATION STRENGTHS AT 296 DEG K, LINE WIDTHS, LOWER STATE ENERGIES, AND IDENTIFYING QUANTUM NUMBERS, IN THE FORMAT OF THE AFCRL ATMOSPHERIC ABSORPTION LINE PARAMETER COMPILATION CALCULATIONS FOR O2 ARE GIVEN IN THE SLAM PROGRAM, AND ALSO FOR CU.**

A62191A*KERKER, M.*LORENZ-MIE SCATTERING*NO #*NO #*21 FEB 1978*NO #*THIS IS A SET OF NOTES M. KERKER GAVE AT THE SMOKE OBSERVATION MODELING SHORT COURSE AT THE UNIVERSITY OF TENNESSEE SPACE INSTITUTE, FEB 21, 1978. IT IS INCLUDED HERE AS IT IS THE LATEST THEORETICAL DISCUSSION PERTINENT TO MODELING OF SCATTERING PHENOMENA OF A LORENZ-MIL TYPE, WHICH IS VALID FOR RAIN, FOGS, PARTICULATES IN THE ATMOSPHERE THAT ARE SPHERICAL OR CYLINDRICAL IN SHAPE, AND WHOSE DROP SIZE/RADIUS SATISFIES THE MIE CRITERION THAT THE RADIUS IS ON THE ORDER OF WAVELENGTH TIMES 2 PI.**

A62691A*MCCLATCHEY, R.A.*ATMOSPHERIC TRANSMISSION MODELING*NO #*NO #*21 FEB 1978*NO #*THIS IS A SET OF TALKS GIVEN BY MACLATCHEY ON 21 FEB 1978 AT A SMOKE OBSERVATION MODELING SHORT COURSE AT THE UNIVERSITY OF TENNESSEE SPACE INSTITUTE ON ATMOSPHERIC TRANSMISSION MODELING. TOPICAL TITLES ARE: ATMOSPHERIC MODELS, OPTICAL DATA (MOLECULAR) AND COMPUTATIONAL TECHNIQUES, OPTICAL DATA (AEROSOLS) INCLUDING COMPLEX RE-

FRACTIVE INDEX, PARTICLE SIZE DISTRIBUTIONS, HUMIDITY EFFECTS - DATA TO 32 UM, LOW SPECTRAL RESOLUTION PROPAGATION (LOWTRAN), AND LASER TRANSMISSION.**

512682J*RUSBRIDGE, M.G.*A NUMERICAL EXPERIMENT ON THE TURBULENT SCATTERING OF MICROWAVE RADIATION BY A TURBULENT PLASMA* NO #*PLASMA PHYSICS, VOL. 10, 95-108*1968*NO #*CALCULATIONS OF THE REFRACTIVE SCATTERING OF RADIATION IN A MEDIUM WITH RANDOMLY VARYING REFRACTIVE INDEX HAVE USUALLY BEEN LIMITED TO THE LINEAR APPROXIMATION WHERE THE SCATTERING IS WEAK. WORT (1966) HAS CONSIDERED STRONG SCATTERING IN THE NON-LINEAR REGIME BUT ONLY FOR VERY RESTYRICTED AND PHYSICALLY UNREALISTIC TYPE OF REFRACTIVE INDEX FLUCTUATION. IN THIS PAPER WE DESCRIBE A NUMERICAL EXPERIMENT DESIGNED TO REMOVE THIS RESTRICTION AND INVESTIGATE A CASE WITH STRONG BUT REALISTIC REFRACTIVE INDEX FLUCTUATIONS. EXAMPLE OF RANDOM SURFACES ARE SET UP AND RAY TRAJECTORIES COMPUTED THROUGH SUCH SURFACES. AN ANGULAR DIFFUSION COEFFICIENT EXPRESSING THE RATE AT WHICH THE MEAN SQUARE DEVIATION INCREASES WITH TRAJECTORY LENGTH IS EVALUATED FROM THE RESULTS AND SHOWN TO BE GIVEN BY AN EXPRESSION VERY SIMILAR TO THAT OBTAINED IN THE LINEAR APPROXIMATION, ALTHOUGH WE WORK IN A STRONGLY NON-LINEAR REGIME.**

215111D*IMAI, I.; SUZUKI, E.; IZAWA, T.; AND KURASHIZE, K.* STATISTICAL PROPERTIES OF RAINFALL AND RADIOWAVE ATTENUATION DUE TO RAIN*NO #*FSTC-725-76 (JAPANESE TRANSLATION)*MAY 1976* AD-B015 583L*THIS 1959 ARTICLE CONSIDERS THE STATISTICAL CORRELATIONS GOTTEN BETWEEN ATTENUATION DUE TO RAIN, AND WAVELENGTH OF THE UWAVES (.9-10 CM) USED. TITLES IN THE ARTICLE ARE: 1) INTRODUCTION, 2) ESTIMATION OF THE SIZE OF RAIN CELL BASED ON AUTO CORRELATION ANALYSIS, 3) MEASUREMENT OF THE SIZE OF THE RAINFALL AREA BY RADAR, 4) ESTIMATION OF RADIO WAVE ATTENUATION PROBABILITY OF AN ARBITRARY LINK BY PROBABILITY DISTRIBUTION OF POINT RAINFALL, 5) RELATION OF PROBABILITY DISTRIBUTION OF 10 MINUTE RAINFALL AND PROBABILITY DISTRIBUTION OF LONGER PERIOD RAINFALL.**

225181G*GODARD, S.*RADIOELECTRIC ATTENUATION PROPERTIES OF RAIN IN THE 0.86 CM BAND*NO #*JOURNAL DE RESERCHES ATMOSPHERIQUES, FRANCE, 121-167 (FTSC-HT-23-0301-15)*FEB 5, 1965*AD-B009 838L *A THEORETICAL ANALYSIS OF THE RADIOELECTRIC PROPERTIES OF RAIN IN THE 0.86 CM BAND IS PERFORMED USING THE STATISTICS OBTAINED BY KERKER ON THE NO. AND SIZE OF RAINDROPS AND THE VALUES OF THE ATTENUATION AND SCATTERING CROSS SECTIONS OF THE DROPS GIVEN BY HERMAN, BROWNING AND BATTON. IT IS ALSO SHOWN THAT THE RATIO BETWEEN ATTENUATION AND INTENSITY IS INDEPENDENT OF DROP SIZE. THE EXPERIMENTAL DEVICES USED TO CHECK THE PROPERTIES OF ATTENUATION IN THE RADIO BAND ARE DESCRIBED. THE GENERAL RESULTS SHOW THAT IT IS POSSIBLE TO OVERLOOK THE ATTENUATION DUE TO ATMOSPHERIC GASES WHEN USING A SHORT BASE OF MEASUREMENTS (UP TO 10 KM). THE INDEX OF REFRACTION FOR WATER AT .86 MM IS TAKEN TO BE M = 3.98 - IX2.37.**

225381I*VOGEL, WOLFHARD*SCATTERING INTENSITY PLOTS AND TRANSMISSION COEFFICIENTS FOR MM WAVE PROPAGATION THROUGH RAIN* CONTRACT NO. F33615-71-C-1203 AFAL-TR-71-345*DEC 1971* AD-890 408L*THIS REPORT PRESENTS THE RESULTS OF COMPUTER

CALCULATIONS OF SCATTERING OF MM RADIO WAVES BY RAIN AND HAIL. POLAR PLOTS OF THE INTENSITY OF SCATTERING ARE SHOWN FOR FREQUENCIES OF 30, 100, 150, AND 300 GHZ IMPINGING ON SINGLE DROPS RANGING IN SIZE FROM 0.55 MM TO 7.0 MM, IN SHAPES FROM 1.0 MM TO 7.0 MM, AND ON DISTRIBUTION OF RAINDROP SIZES ASSORTED WITH RAINFALL RATES FROM 0.25 MM/HR TO 150 MM/HR. IN ADDITION, TABLES ARE PRESENTED FOR THESE FREQUENCIES AND THESE RAINFALL RATES OF THE ATTENUATION FROM ABSORPTION FROM SCATTERING THEIR COMBINATIONS. THE FRACTIONS OF ENERGY BACKSCATTERED AND FORWARD SCATTERED PER UNIT SOLID ANGLE ARE ALSO TABULATED FOR THE RAIN RATES STUDIED. INDICES OF REFRACTION FOR WATER AND ICE ARE GIVEN (TABLE 2, PAGE 9) AT FREQUENCIES OF 30, 100, 150, AND 300 GHZ.**

226311C*LAMMERS, UVE*INVESTIGATIONS ON THE EFFECTS OF PRECIPITATION ON MM WAVE PROPAGATION: A PHD THESIS*NO #*TECHNICAL UNIV. BERLIN, (WEST) GERMANY*9 SEPT 1975*AD-B006 925L*SCATTERING AND TOTAL CROSS SECTIONS ARE COMPUTED, FOR LAMBDA = 5 MM, FOR ALL RELEVANT VALUES OF THE COMPLEX REFRACTIVE INDEX AND OF THE RATIO OF THE CIRCUMFERENCE TO THE WAVELENGTH. POLARIZATION DEPENDENT EFFECTS ARE STUDIED WITH A SIMPLE APPROXIMATION. MEASUREMENT MADE WITH FM RADAR FOR RAIN, FOG, AND DRY SNOW AGREE SATISFACTORILY WITH COMPUTED VALUES. THE RESULTS OF BACKSCATTER STUDIES ARE ALSO REPORTED. DEBYE'S THEORY FOR THE DIELECTRIC CHARACTERISTICS OF WATER AND ICE ARE USED IN THE CALCULATIONS. 24 REFS.**

C341119*RICHARD, VICTOR W.*MM WAVE RADAR APPLICATION TO WEAPON SYSTEMS*NO #*BRL REPORT 2631*JUNE 1976*AD-B012 103L*APPLICATIONS OF MM WAVE RADAR IN GROUND TO AIR, GROUND TO GROUND, AND AIR TO GROUND WEAPONS SYSTEMS ARE PRESENTED. THE ADVANTAGES AND LIMITATIONS OF OPERATING ON MM WAVELENGTHS ARE DEFINED (FREQUENCY REGION 70-140 GHZ). THE CHARACTERISTICS OF MM WAVE RADAR PROPAGATION IN ADVERSE WEATHER ARE DESCRIBED WITH EMPHASIS ON RAIN BACKSCATTER AND ATTENUATION THEORY, EXPERIMENTAL DATA, AND RAIN EFFECTS ON RADAR PERFORMANCE.**

425181C*GAMBLE, WM. L. AND HODGENS, TONY E.*PROPAGATION OF MM AND SUB MM WAVES*NO #*REDSTONE ARSENAL REPORT TE-77-14*JUNE 1977*AD-B023 622L*THIS REPORT PRESENTS THE RESULTS OF A LITERATURE SURVEY OF THE EFFECTS OF THE ATMOSPHERE ON MM AND SUB MM WAVE PROPAGATION. THE REGIONS INVESTIGATED WERE CONFINED TO A RANGE OF 35 GHZ TO 408 GHZ (735 UM TO 8.57 MM). A SURVEY OF EXISTING THEORETICAL AND EXPERIMENTAL DATA IS PRESENTED FOR VARIOUS ATMOSPHERIC CONDITIONS. METEOROLOGICAL UNCERTAINTIES AND THEIR EFFECTS ON ATTENUATION MEASUREMENTS ARE DESCRIBED. AREAS WHERE SUPPLEMENTAL DATA ARE REQUIRED FOR AN UNDERSTANDING SUFFICIENT TO THE NEEDS OF THE SYSTEMS ENGINEER ARE PRESENTED. 50 REFS.**

524111B*BARRY, GEORGE; WOODBURY, DICK; AND ROWE, PETER*AN INVESTIGATION OF REPORTED OVER-THE-HORIZON PROPAGATION AT 35 GHZ*NO #*NO #*DEC 1974*AD-B003 692L*AN EXPERIMENTAL AND THEORETICAL INVESTIGATION OF A RUSSIAN ARTICLE "REFRACTIVE QUALITIES OF THE STRATOSPHERE LAYER EXPOSED TO CIRCULAR POLARIZED RADIO WAVES INTHE 30-45 GHZ BAND" BY V.A. KIVNYEVSKIY WAS DONE TO DETERMINE ITS VERACITY. THEORETICALLY, IT WAS IMPOSSIBLE! EXPERIMENTALLY AT 35 GHZ, THE

PATH LOSS WAS 70 DB MORE THAN IS REQUIRED TO HAVE A READABLE SIGNAL. CONCLUSION: 1) REPORT A HOAX OR 2) CONDITIONS EXIST ONLY IN SIBERIA.**

524181 *ALT, JAMES S.*ATMOSPHERIC EFFECTS ON MM WAVE PROPAGATION*CONTRACT NO. F33615-70-C-1301*AFAL-TR-71-283*1 OCT 1971* AD-889 104L*LINE OF SIGHT TROPOSPHERIC PROPAGATION OF E & M SIGNALS IS LIMITED BY AMPLITUDE AND PHASE FLUCTUATIONS INDUCED BY RANDOM REFRACTIVE CHANGES OF THE ATMOSPHERE IN THE PROPAGATION PATH. A DESCRIPTION OF A DUAL ANTENNA SYSTEM FOR DETECTING AMPLITUDE AND PHASE DISTURBANCE INDUCED ON AN UNMODULATED 69 GHZ CARRIER IS PRESENTED. THE PHASE DIFFERENCE BETWEEN THE SIGNAL RECEIVED BY THE TWO ANTENNAS CAN BE USED TO CALCULATE WAVEFRONT TILTS AND ANGLE OF ARRIVAL FLUCTUATION. A COMPUTER PROGRAM WHICH PERFORMS A STATISTICAL ANALYSIS OF THE DATA AND COMPUTER TATERSKI'S STRUCTURE FUNCTION IS DISCUSSED.**

564161A*LANE, D.*FEASIBILITY STUDY REPORT BY NIAG SUB-GROUP 5 ON THE ACQUISITION AND IDENTIFICATION OF MARITIME SURFACE TARGETS WITHOUT THE USE OF RADAR; VOL. III, MATHEMATICAL MODEL*NO #*NIAG(76)D/4, VOL. 3; 4 MARCH 1977*JAN 28, 1978* AD-B024 377L*THIS IS A TV AND IR (8-12 MM) MODEL BASED ON AN ENGAGEMENT SCENARIO OF AN AIRCRAFT SEARCHING FOR SHIP-TYPE TARGETS THROUGH AN ATMOSPHERE SCATTERING AND ATTENUATING THE VISIBLE AND IR LIGHT WHICH IS EMITTED OR REFLECTED FROM THE TARGET. FROM THE MODELS, IT IS APPARENT THAT LOW LIGHT TVS ARE BEING MODELED.**

5651A19*FINN, R.S.; STANTON, M.J.; AND STEPHENS, T.L.*ENVIRONMENTAL EFFECTS - LASERS (EEL) CODE MODEL DEVELOPMENT PLAN* DA5G60-77-C-0044*GE77TMP-31*NOV 17, 1977*AD-B022 974L*A MODEL DEVELOPMENT PLAN FOR THE ENVIRONMENTAL EFFECTS - LASER (EEL) COMPUTER PROGRAM IS DESCRIBED. THE PROGRAM MODELS LASER PROPAGATION IN THE AMBIENT AND NUCLEAR DISTURBED ATMOSPHERE, THE OUTPUT BEING APPLICABLE TO THE ANALYSIS OF LADAR AND LASER WEAPONS SYSTEMS USED IN BALLISTIC MISSILE DEFENSE.**

A241819*WEATHERS, G. AND GRAF, E.R.*DESIGN OF EXPERIMENTS TO CHARACTERIZE THE PROPAGATION OF MILLIMETER WAVES ON AEROSOLS* NO #*M AND S COMPUTING INC., REPORT 77-107*SEPT 1977*AD-B021 851L*THIS REPORT INCLUDES THE DESCRIPTION OF SEVERAL EXPERIMENTS TO CHARACTERIZE THE PROPAGATION OF ELECTROMAGNETIC RADIATION AT MM WAVELENGTH (APPARENTLY 70-140 GHZ), THROUGH AEROSOLS, SMOKE. A DETAILED LIST OF EQUIPMENT IS INCLUDED. NO DATA WAS TAKEN, AS THE PURPOSE WAS TO OUTLINE THE EXPERIMENTAL SETUP NEEDED TO DO THE JOB.**

A64191K*DINERMAN, C.E.; LOHKAMP, C.; AND JOHNSON, D.*AEROSOL OBSCURANT MEASUREMENT CAPABILITIES*NWSC/CR/RDTR-43*NO #* OCT 1976*AD-B015 065L*THE PURPOSE OF THIS REPORT IS TO VALIDATE THE CAPABILITY OF NAVWPNSUPPLEN CRANE TO MEASURE TRANSMITTANCE OF AEROSOL OBSCURANTS IN THE VISIBLE AND IR AS WELL AS PARTICLE SIZE DISTRIBUTION BOTH IN THE LABORATORY AND IN THE FIELD. THIS REPORT DESCRIBES THE PROCEDURES AND INSTRUMENTATION UTILIZED FOR THE MEASUREMENTS AND PRESENT DATA TO PROVIDE EXAMPLES OF THE TYPE OF INFORMATION WHICH CAN BE OBTAINED. NAVWPIVCENCRANE HAS THE CAPABILITY TO MAKE LABORATORY AND FIELD SPECTRAL AND/OR RADIOMETRIC TRANSMIT-

TANCE MEASUREMENTS, AS WELL AS PARTICLE SIZE DISTRIBUTIONS OF MATERIALS THAT MAY BE USED AS AEROSOL OBSCURANTS. SPECTRA CAN BE TAKEN (AS FAST AS 1000 SPECTRA/SEC) IN THE 0.65-1.79 UM, 1.7-4.7 UM AND 9-14 UM REGIONS. RADIOMETRIC DATA CAN BE TAKEN IN THE VISIBLE, .9-1.06 UM, .96-2.69 UM, 3-5 UM, AND 8 UM REGIONS. OTHER REGIONS ARE ACCESSIBLE BY FILTER CHANGES. THE PARTICLE SIZES THAT CAN BE MEASURED RANGE FROM .009 TO .5 UM USING AN AEROSOL ANALYZER, AND 1 UM UPWARDS USING A FILTER COLLECTION SYSTEM**

A64381D*SARKISOV, S.L. AND STEPONOV, S.I.*FTD-ID-(RS)T-0314-77* NO #*DEC 7, 1977*AD-B023 365L*THIS REPORT COVERS DISTANCE MEASUREMENTS NATURALLY OCCURRING AEROSOLS WITH THE AID OF TWO-STAGE CONDENSATION IMPACTER TRAPS, WITH THE PARTICLE SIZE COLLECTED BEING FROM .01 MESOMETERS TO 10. OF MICRONS. FLIGHTS WERE CONDUCTED AND IN THE FOLLOWING REGIONS; DESERT IN THE CITY DISTRICT OF SHEVCHERKO, KRASNOVODSKI; CASPIAN SEA, THE NORTH CAVACASUS IN THE REGION OF MAKHACHKALA, KIZLYAR, STAVROPOL, NOLISHIK, KRASNODAR; BLACK SEA. SAMPLES WERE TAKEN AT HEIGHTS OF 50, 100, 500, 1000, 1500 METERS - UP TO 5500 METERS ABOVE SEA LEVEL. MICROPHYSICAL MEASUREMENTS WERE ACCOMPANIED BY THE MEASUREMENTS OF THE PARAMETERS OF THE STATE OF THE ATMOSPHERE.**

A65391C*HANCOCK, J. HARRISON AND LIVINGSTON, PETER M.*PROGRAM FOR CALCULATING MIE SCATTERING FOR SPHERES USING KERKER'S FORMULATION, OVER A SPECIFIED PARTICLE SIZE DISTRIBUTION* NO. #*NRL REPORT NO. 7808*NOV 21, 1974*AD-B000 656L*A FORTRAN PROGRAM HAS BEEN WRITTEN FOR CALCULATING THE MIE SCATTERING FOR SPHERES WITH A COMPLEX INDEX OF REFRACTION. THE SCAT-TERED POWER IS EXPRESSED NUMERICALLY AS A CONVERGENT SERIES AND THE RESULT IS INTEGRATED OVER A GIVEN PARTICLE DISTRIBU-TION. THE PROGRAM PROVIDES TWO OPTIONS: A) SCATTERED IN-TENSITIES IN A DIRECTION GIVEN BY THE POLAR ANGLE AND THE COLATITUDE, AND B) INTENSITY FUNCTIONS DEFINED IN TERMS OF INTEGRALS WITH RESPECT TO THE MIE SIZE PARAMETER.**

A661961*RUHNKE, LOTHER H., EDITOR*PROCEEDINGS OF A WORKSHOP ON REMOTE SENSING OF THE MARINE ENVIRONMENT*F52331*NRL REPORT NO. 3430*JUNE 1977*AD-B023 449L*THIS REPORT CONTAINS PAPERS PRE-SENTED AT A MEETING ON NAVY NEEDS IN REMOTE SENSING AND THE STATE-OF-THE-ART OF ATMOSPHERIC REMOTE SENSING. PRESENTATIONS WERE GIVEN ON A DEGRACTION OF THE MARINE ENVIRONMENT, NAVY NEEDS FOR ATMOSPHERIC MEASUREMENTS, AND ACTIVE AS WELL AS PASSIVE REMOTE SENSING USING IR, MICROWAVES AND ACOUTICS TECHNIQUES.**

A661816*SIGEL, V.L. AND DUKHIN, S.S.*AEROSOLS, OUR FRIENDS, OUR ENEMIES*FTD-ID(RS)T-0977-77*NO #*JUNE 1977*AD-B023 139L* THIS IS A LONG RAMBLING DISCUSSION ON AEROSOLS BY TWO RUSSIAN AUTHORS. THEY DISCUSS HOW AEROSOLS ARE MADE, MEASURED (VI-SIBLE LIGHT) AND WHAT SUBSTANCES CAUSE AEROSOL FORMATION IN THEIR MANUFACTURING PROCESSES.**

A66461A*IVLEV, L.S.; YANCHENKO, YE.L; AND SPAZHAKINU, M.K.* EFFECTS OF THE MICROSTRUCTURE AND SIZE DISTRIBUTION OF AERO-SOL PARTICLES AND OPTICAL PROPERTIES OF AEROSOLS*NO #*FSTC-1668-75*13 DEC 1975*AD-B013 655L*THE AUTHORS DISCUSS CALCU-LATED DATA ON THE OPTICAL PROPERTIES OF ABSORBING POLY DIS-PERSED ATMOSPHERIC AEROSOLS. CORRELATIONS BETWEEN THE AERO-

SOL STRUCTURE AND THE OPTICAL PROPERTIES ARE POINTED OUT. CONCLUSIONS ARE PRESENTED ON THE POSSIBILITY OF INVESTIGATING THE AEROSOL STRUCTURES BY MEANS OF EXPERIMENTAL EXTINCTION AND INTERPRETATION OF BACKSCATTERING DATA.**

B641617*SUDNUZAROU, KH.E.*THE VERTICAL EXTENT OF HAZE LAYER OVER CENTRAL ASIA*NO #*FSTC-0367-76*28 NOV 1976*AD-B017 158L THIS DESCRIBES A SET OF AIRCRAFT OBSERVATIONS OF HAZE AND DUST STORM OVER THE TASHKENT OF RUSSIA. THE AUTHOR RELATES THE AIR PRESSURE AND WIND CONDITIONS TO THE FORMATION OF THESE HAZES AND DUST STORMS. DATA OF THIS TYPE IS PROFITABLE FOR USE AS A MODEL FOR MM WAVING LIGHT TRANSMISSIONS.**

C141718*CREPEAU, PAUL J.*TOPICS IN NAVAL TELECOMMUNICATIONS MEDIA ANALYSIS*NO #*NRL REPORT NO. 8080*DEC. 31, 1976*AD-B016 496L*TO MEET ITS MISSION REQUIREMENTS, THE NAVY EMPLOYS VARIOUS FORMS OF TRANSMISSION MODES THROUGHOUT THE FREQUENCY CONTINUUM. IN THIS REPORT, DATA FROM SEVERAL RECENT MEDIA STUDIES ARE COLLATED TO PROVIDE A BASIS FOR ASSESSING TRANSMISSION PERFORMANCE IN THE DIFFERENT FREQUENCY BANDS AND ASSOCIATED MEDIA. BANDS: HF THROUGH 35 GHZ.**

C241118*FORAL, M.*MILLIMETER RADAR INVESTIGATION*NO #*NADC-20-73013*26 MAR 1973*AD-910 157L*THIS IS A TEST REPORT ON THE FIRST EFFECTIVE 95 GHZ RADAR THAT WAS CONDUCTED WITH VARIOUS TARGETS OVER LAND, SNOW AND WATER. THE RESULTS OF THESE TESTS AND POSSIBLE APPLICATIONS OF THE RADAR ARE DISCUSSED. SYSTEM PERFORMANCE FIGURES, RELATING TO DB ABOVE MINIMAL DESIRABLE SIGNAL, FOR A VARIETY OF TARGET, CORNER REFLECTORS TO NO. 26 COPPER WIRE ARE GIVEN.**

C24111C*ZIZZO, E.A.; KRICEK, J.V.; SOONG, A.; AND KOESTER, K.L.*MM SURVEILLANCE RADAR FOR THE MINI RPV*CONTRACT NO. DAAB07-76-C-0843*NO #*30 JUNE 1977*AD-B020 114L*A 95-GHZ SURVEILLANCE RADAR BRASS BOARD HAS BEEN DESIGNED, FABRICATED AND TESTED. IT IS A FUNCTIONAL REPRESENTATIVE OF A MINIATURIZED PRODUCTION 95 GHZ RADAR SYSTEM CARRIED ABOARD A MINI RPV. THE TACTICAL FUNCTION OF THE SENSOR IS TO DETECT AND RECOGNIZE HARD TARGETS SUCH AS TANKS, TRUCKS, AND ARTILLERY PIECES IN THE COMBAT ZONE BEYOND THE FORWARD EDGE OF THE BATTLE AREA (FEBA). THIS REPORT DESCRIBES THE MM RADAR BRASS BOARD, ITS ASSOCIATED INSTRUMENTATION, GROUND TESTING RESULTS, AND RECOMMENDATIONS.**

C24112C*KAPUSCIENSKI, STANLEY J., ET AL.*MILLIMETER WAVE COMMUNICATIONS PROGRAM: LINK TEST OF HIGH-SPEED DIGITAL RADIO SET AN/GRC-173(XW-1)*NO #*RADC-TR-74-329*JUN 1975*AD-B002 666L*THIS DESCRIBES THE RESULTS OF FIELD TESTING THE AN/GRC-173(XW-1) RADIO SET IN THE WASHINGTON. DC AREA. THIS SET OPERATING IN THE 36-38 TO GHZ BAND, HAVING A BAND WIDTH OF 236 MEGABITS/SEC. PROPAGATION DATA SHOWED THAT THIS RADIO (LINE OF SIGHT) RECEPTION PATH AVAILABILITY WAS 99.99% FOR A 3-MONTH PERIOD WHICH INCLUDED RAINFALL, SNOW, AND FOG. THE CONCLUSION DRAWN WAS THAT THIS SET FULFILLED ITS DESIGN REQUIREMENTS FOR LINE-OF-SIGHT COMMUNICATIONS.**

C24171A*TSAO, K.H.*KA BAND SATELLITE COMMUNICATIONS SET AN/ASC-22*F33615-73-C-4036*MAR 1976*AD-B016 243L*THIS REPORT DESCRIBES THE DESIGN AND DEVELOPMENT OF THE KA BAND SATELLITE COMMUNICATIONS SET, AN/ASC-22. THE SET

OPERATES IN THE 36-38.3 GHZ BAND AND IS FOR AIRBORNE COMMUNICATIONS EXPERIMENTS WITH THE LINCOLN EXPERIMENTAL SATELLITES LES-8 AND LES-9. THIS TERMINAL INCLUDES AN UP-LINK TRANSMITTER, DOWN-LINK RECEIVER, FREQUENCY GENERATION SYSTEM, AND A HIGH TRANSMITTANCE RADOME FOR A C-135 AIRCRAFT.**

C24311F*SOONG, A.A.; CANELI, J.M.; KOSOWSKY, L.H. AND KOESTER, K.L.*MM RADAR TEST PROGRAM*CONTRACT NO. DAAH01-R-0010*NORDEN REPORT TE-CR-77-6*APRIL 27, 1976*AD-B017 830L*A SERIES OF RADAR EXPERIMENTS ON TARGET CROSS SECTION AND POLARIZATION CHARACTERISTICS HAS BEEN PERFORMED AT 4.3 MM WAVELENGTH. THESE TACTICAL TARGETS (TANKS, ARMORED PERSONNEL CARRIER, AND JEEP) AND FOUR DIFFERENT CLUTTER BACKGROUNDS (MEADOW, SHRUBBERY, BRUSH, AND WOODS) WERE EMPLOYED FOR THE EXPERIMENT. TWO RADAR PARAMETERS WERE VARIED IN THE MEASUREMENT PROGRAM; NAMELY, PULSEWIDTH (20, 45, AND 70 NS), AND POLARIZATION. TARGET AND CLUTTER CROSS SECTION (PLS) AND AMPLITUDE DISTRIBUTION WERE INVESTIGATED AS A FUNCTION OF ASPECT ANGLE, PULSEWIDTH AND POLARIZATION. FIXED TARGET ENHANCEMENT TECHNIQUES WERE EXAMINED USING A PULSE TO PULSE DIVERSITY PRINCIPLE.**

C24771D*WILT, ROBERT L.*94 GHZ RADIOMETER*CONTRACT NO. F33615-76-C-1173*NO #*JUNE 1977*AD-B020 739L*A 94 GHZ UWAVE RADIOMETER WAS DESIGNED, FABRICATED AND TESTED. A PROPAGATION MEASUREMENT SENSITIVITY OF 3.5 DEG K WAS ACHIEVED WITH A 150 HZ OUTPUT BANDWIDTH. RADIOMETER NOISE FIGURE AND IF BANDWIDTH WERE 12.3 DB AND 730 MHZ. GOVERNMENT FURNISHED IMPATT LOCAL OSCILLATOR AND MIXER USING A WIRE EVALUATOR AND INCORPORATED INTO THE RADIOMETER. THE RADIOMETER IS AN ACCOUPLED TOTAL POWER RADIOMETER WITH PERIODIC CALIBRATION AND AGC. AN INPUT DIODE OPERATING STRICTLY OPERATIONS VS A NOISE GENERATOR WAS SUCCESSFULLY EMPLOYED AS AN AGC REFERENCE SOURCE WITH COMPENSATION FOR ENVIRONMENTAL TEMPERATURE SENSITIVITY.**

C341B19*NO #*SUBMILLIMETER WAVE SUBSYSTEMS*NO #*SCIENCE APPLICATIONS, INC./U.S. ARMY MISSILE R&D COMMAND, REDSTONE ARSENAL*30 SEPT 1977*AD-B021 010L*THIS DESCRIBES A SUB MM WAVE AND RECEIVER; 2-CO2 LASERS ARE USED TO GENERATE A DIFFERENCE FREQUENCY IN THE SUB MM REGION (EXACT BAND NOT GIVEN). THE ELECTRONIC CIRCUITRY ARE GIVEN, IN DETAIL, THAT WERE USED TO PHASE LOCK THE 2-CO2 LASERS TOGETHER WITH PZT PIEZOELECTRIC DEVICES IN A FABRY PEROT-LASER CAVITY.**

C361B18*WERNER, B; BELANGER, B.; DOMIZIO, R.D.; AND SMITH, P.*MILLIMETER SEMIACTIVE GUIDANCE SYSTEM*NO #*NOV 1976*AD-B017 829L*THE CONCEPT INVOLVES THE USE OF A MM ILLUMINATOR MOUNTED ON AN RPV AIRCRAFT ON THE GROUND, ILLUMINATING A GROUND VEHICLE SEEKER TARGET, AND A SEEKER MOUNTED IN A PROJECTILE OR SIMILAR WEAPON AND GUIDING THE WEAPON TO THE ILLUMINATED TARGET. TRADEOFF STUDIES WERE CONDUCTED TO DETERMINE THE OPTIMUM ILLUMINATOR WAVEFORM AND OPTIMUM SEEKER DESIGN. ANALYSIS OF DETECTION CAPABILITIES AND TRACKING ACCURACY WERE PERFORMED FOR BOTH CLEAR WEATHER AND ADVERSE WEATHER CONDITIONS.**

C445818*TYSL, VACLAV*NEW PRINCIPLES FOR THE CONTRUCTIONS OF

SOME MICROWAVE COMPONENTS IN THE MM AND SUB MM WAVELENGTH REGION*NO #*12TH INTERNATIONAL SCIENTIFIC SYMPOSIUM, TECHNICAL COLLEGE, ILMENOUR, EAST GERMANY, 1967, (FTSC-0059-75)*12 AUG 1975*AD-B010 324L*THE AUTHOR DESCRIBES SEVERAL MM WAVE REFLECTOMETER DEVICES THAT MAY BE OF VALUE FOR MEASUREMENTS OF DIELECTRIC CONSTANTS IN THE MM SUB MM WAVELENGTH REGION: QUASI-OPTICAL TECHNIQUES ARE USED.**

D15111B*FANSLER, KEVIN S.*ON THE FREE ELECTRON DENSITY IN A NUCLEAR BLAST ENVIRONMENT*NO #*BRL-MR-2688*11 SEPT 1976*AD-B014 240L*A TECHNIQUE IS PRESENTED FOR INCLUDING TRANSPORT EFFECTS IN CALCULATING THE FREE ELECTRON DENSITIES IN A NUCLEAR BLAST WITH A MODIFIED WEPH-D CODE. TRANSPORT EFFECTS FOR DIFFERENT ALTITUDES AND TIMES ARE SHOWN AND DISCUSSED. IN ADDITION, A METHOD HAS BEEN DEVELOPED TO ESTIMATE AN UPPER BOUND DISTANCE FROM EQUILIBRIUM IN A NUCLEAR BLAST. BY APPLYING BLAST WAVE SCALING THEORY, THE ELECTRON DISTRIBUTION WAS FOUND TO BE NEAR EQUILIBRIUM IN A SPECIFIC REGION; THE BLAST WAVE MAY THEN BE APPROXIMATED.**

543181 *MCCLATCHEY, R.M., ET AL.*NO #*ATMOSPHERIC ABSORPTION LINE PARAMETER COMPILATION*A.F. CAMBRIDGE LABS, AFCRL-TR-73-0096*1973*NO #*THIS IS A MAGNETIC TAPE OF OVER 109,000 KNOWN TRANSACTIONS OF H20, O3, O2, CO2, CO, N20, AND CH4 BETWEEN 0.76 UM AND 3.26 MM, WITH A FEW EXCEPTIONS. COPIES OF THIS TAPE ARE AVAILABLE FOR $60 FROM U.S. DEPARTMENT OF COMMERCE, NATIONAL CLIMACTIC CENTER, FEDERAL BUILDING, ASHVILLE, NORTH CAROLINA 28801.**

A62192E*BAKER, L.RAY; AND PINKLEY, LARY W.*A GUIDE FOR USERS OF THE JTCG/ME SMOKE OBSERVATION MODEL II: SOM II COMPUTER CODE*CONTRACT NO. DAAK40-77C-0141*LMSC-HREC-TR, D568206*FEB 1978*NO #*THIS IS A COMPUTER CODE USAGE GUIDE FOR A VISIBLE (.4-.7 UM) AND I.R. (.7-14.0 UM) SMOKE OBSERVATION MODEL, SOM II. THIS MODEL HAS IN IT A MUNITION DISPERSAL MODULE, A CONTROL MODULE, AN OPTICS MODEULE (WHICH CONTAINS PARTICLE SIZE DISTRIBUTION MODELS, MIE MODEL, ATMOSPHERIC AND ADVERSE WEATHER MODELS INCLUDING THE LOWTRAN IIIB NWC/LOWTRAN COMPUTER MODEL, A SENSOR MODULE, MECHANICAL MODULE, AND PERCEPTION MODULE. IT APPEARS THAT A GOAL OF MM WAVE MODELING WOULD BE TO GENERATE AN "OPTICS MODULE" SO THAT A PROGRAM LIKE THIS WOULD APPLY TO MM WAVES AS WELL.**

A61191E*NO #*JOINT TECHNICAL COORDINATING GROUP FOR MUNITIONS EFFECTIVENESS: SMOKE-AN OBSERVATION PRIMER*CONTRACT NO F08635-77-C-0273*61 JICG/ME-77-13*4 NOV 1977*NO #*THIS IS A CONFERENCE PROCEEDING ON SMOKE OBSERVATION GIVEN AT A SHORT COURSE ON SMOKE OBSERVATION, AT THE UNIVERSITY OF TENNESSEE SPACE INSTITUTE, FEB 21-22, 1978. THE PURPOSE OF THIS SET OF TALKS IS TO ACQUAINT U.S. MILITARY PERSONNEL AND CONTRACTORS WITH THE MILITARY USAGES OF SMOKE. IT DESCRIBES THE CHEMICAL CONSTITUENTS OF ORDINARY OBSCURANTS, SOVIET MILITARY PRACTICES, AND U.S. MILITARY USES. NO MENTION OF FAR IR OR MM WAVES IS MADE HERE; THIS IS INCLUDED AS A SOURCE DOCUMENT FOR THE TYPES OF CHEMICALS THAT SHOULD BE INCLUDED IN FUTURE FAR IR - SUB MM MODELING OF ATMOSPHERIC TRANSMISSION.**

A625817*BALDASSARE DIBARTOLO*OPTICAL INTERACTIONS IN SOLIDS*JOHN

WILEY CO.*NO #*1968*NO #*"THE PURPOSE OF THIS BOOK IS TO PROVIDE PHYSICISTS WORKING WITH LASERS AND ABSORPTION AND FLOURESENCE SPECTROSCOPY WITH A THEORETICAL BACKGROUND".... TOPICS DISCUSSED RELATE TO CALCULATION OF ABSORPTION AND LOSS IN DIELECTRICS AND EMISSION OF LIGHT, AND ARE OF INTEREST IN MM AND SUB MM DIELECTRIC CALCULATIONS**

A325816*MAX BORN AND KUN HUANG*"DYNAMICAL THEORY OF CRYSTAL LATTICES"*OXFORD, CLARENDON PRESS*NO #*1954*NO #*THIS TEXT DISCUSSES THE DIELECTRIC BEHAVIOR OF MANY OF THE CRYSTALS OF IMPORTANCE RE-AEROSOL SCATTERING AND ATTENUATION, AND IS A SOURCE BOOK OF CALCULATIONS OF INDEX OF REFRACTION AND DIELECTRIC CONSTANTS**

A335A16*THOMAS S. HARTWICK AND DEAN T. HODGES, EDS'.*"FAR IR/ SUB MM WAVE TECHNOLOGY / APPLICATIONS"*VOL. 105, PROCEEDINGS OF THE SOCIETY OF PHOTO-OPTICAL INSTRUMENTATION ENGINEERS* *NO #*APRIL 1977*NO #*THIS IS A COLLECTION OF PAPERS GIVEN APRIL 18-21, 1977 AT RESTON VA. MOST OF THE ARTICLES WOULD BE OF APPLICATION HERE SO WILL NOT BE LISTED SEPARATELTY**

113181J*DARRELL E. BURCH*ABSORPTION OF IR RADIANT ENERGY BY CO2 AND H2O III. ABSORPTION BY H2O BETWEEN 0.5 AND 36 CM-1(278 UM-2 CM)*NO #*J.O.S.A. VOL 58 NO. 10,P 1383-1394*NO #*OCT. 1968* INTERFEROMATIC TECHNIQUES HAVE BEEN EMPLOYED TO MEASURE THE H2O ABSORPTION BETWEEN APPROXIMATELY 12.6 CM-1 AND 36.0 CM-1. THE EXPERIMENTAL RESULTS, ALONG WITH RESULTS OBTAINED BETWEEN 0.5 CM-1 AND 10 CM-1 BY OTHER WORKERS, HAVE BEEN COMPARED WITH CALCULATED VALUES OF TRANSMITTANCE BASED ON THEORETICALLY DETERMINED POSITIONS, STRENGTHS, WIDTHS, AND SHAPES OF ABSORPTION LINES. FROM THESE COMPARISONS IT HAS BECOME APPARENT THAT NONE OF THE WELL-KNOWN THEORETICAL LINE SHAPES ARE CORRECT FOR THE EXTREME WINGS OF THE H2O LINES BELOW APPROXIMATELY 40 CM-1. THE AMOUNT OF CONTINUUM ABSORPTION WHICH MUST BE ADDED TO THE THEORETICAL ABSORPTION COEFFICIENT TO PROVIDE AGREEMENT WITH THE EXPERIMENTAL RESULTS HAS BEEN DETERMINED FOR N2 AND SELF-BROADENED LINES. A TABLE OF THE LINE PARAMETERS HAS BEEN IN-CLUDED, ALONG WITH A DISCUSSION OF THE PROCEDURE TO BE FOLLOWED IN CALCULATING THE TRANSMITTANCE OF HOMOGENOUS AND INHOMOGENOUS PATHS**

A63561M*THOMAS H. NYMAN, KENNETH W. RUGGLES, ET.AL., EDITORS* "PROCEEDINGS OF THE OPTICAL-SUB MM ATMOSPHERIC PROPAGATION CONFERENCE", VOL I, UNCLASSIFIED PROCEEDINGS, 6-9 DEC. 1976, A. F. ACADEMY*NO #*DEC 1976*NO #*THIS REPORT IS ONE OF A 2 VOL. SET SUBMITTED FOR PRESENTATION AT THE OPTICAL-SUB MM ATMOSPHERIC PROPAGATION CONFERENCE HELD AT THE U.S.A.F. ACADEMY ON 6-9 DEC. 1976. VOL.I CONTAINS ALL THE UNCLASSIFIED PAPERS. VOL.II CONTAINS THE CLASSIFIED PAPERS. PAPERS OF RELEVANCE TO MM AND SUB MM WAVE PROPAGATION IN VOL.I ARE AS FOLLOWS; #3,"SUB MM WAVE PROPAGATION A SURVEY", BY W.L. GAMBLE AND B.D. GUNTHER; #4, "SUB MM SYSTEM FOR IMAGING THROUGH INCLEMENT WEATHER" , BY R. HARTMANN, W.L. GAMBLE, ET.AL; #9, "ATMOSPHERIC TRANSMISSION MODELING: PROPOSED AEROSOL METHODOLOGY WITH APPLICATION TO THE GRAFENWOHR ATMOS-PHERIC OPTICS DATA BASE", ROBERT E. ROBERTS.; #10, "COMPLEX REFRACTION INDEX OF ATMOSPHERIC PARTICULATE MATTER---", JAMES D. LINDBERG AND JAMES B. GILLESPIE; #14, "THE NATURE OF GUN SMOKE AND DUST OBSCURATION DUE TO CANNON FIRING", E.W. STUEBERG ET.AL.; #15, "OPTICAL AEROSOL MODELS AND LIGHT SCATTERING PRO-

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5111799*BERNARD GOLDBERG AND JAMES MINK*COMMUNICATION CHANNELS CHARACTERIZATION AND BEHAVIOR" PART IX, MILLIMETER WAVES*IEEE PRESS, REPRINT VOLUME*NO #*1976*NO #*THIS IS A COLLECTION (4) OF REPORTS ON MM WAVE COMMUNICATIONS, AND A BIBLIOGRAPHY OF 100 REFERENCES ON MM WAVE PROPAGATION, TECHNOLOGY, DEVICES, CHANNEL MODELING. THE 4 REPRINTS OF THE BIBLIOGRAPHICAL COLLECTION ARE; "THE THEORY OF M WAVE LINE OF SIGHT PROPAGATION THROUGH A TURBULENT ATMOSPHERE", S. CLIFFORD, IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, "PROPAGATION STUDIES IN MM WAVE LINK SYSTEMS", G.E. WERBEL AND H.O. DRESSEL, PROC. IEEE, APRIL '67, "PROPAGATION PHENOMENON AFFECTING SATELLITE COMMUNICATIONS SYSTEM OPERATING IN THE CM AND MM WAVE LENGTH BANDS", R.K. CRANE, "PROC. IEEE FEB. '71, AND "CHARACTERISTICS OF AN EXPERIMENTAL GUIDED MM WAVE TRANSMISSION SYSTEM", K. MIYASUCHI, ET.AL., IEEE TRANS. COMM., AUG. '72**

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